A FRAMEWORK FOR ADOPTING SOLAR ENERGY GOVERNANCE IN THE NIGERIAN POWER SECTOR

Dahiru Abdullahi, BSc, MSc, FHEA

A thesis submitted in partial fulfilment of the requirements of the University of Wolverhampton for the degree of Doctor of Philosophy

Faculty of Science and Engineering
University of Wolverhampton

June 2021

This work or any part thereof has not been previously presented in any form to the University or to any other body for the purpose of assessment, publication or any other purpose. Unless indicated for any express acknowledgement, reference, and or/ bibliographies cited in the work, I confirm that the intellectual content of the work is the result of my own efforts and of no other person.

Signature……*Dahiru*…… Date……**10th June 2021**……

Abstract

The Nigerian economy is almost exclusively dependent on oil and gas as more than 80% of its revenue is currently generated from this sector. However, lack of stable electricity from all sources has impacted the socio-economic growth over a long period of time. This research explores the drivers, barriers and benefits of implementing solar energy strategies. In doing so, a framework for adopting solar energy governance in the Nigerian power sector was developed based on literature review and findings from the semi-structured interview held with 25 top management officials of solar energy stakeholders in Nigeria. The philosophical position of this research is inductive approach and interpretivist paradigm. The qualitative data collection method was employed, data were interpreted and analysed using content analysis. Interpretive Structure Modelling (ISM) was used further to analyse the barriers for solar energy implementation in Nigeria. The study revealed that socio-cultural aspects, lack of financing and lack of awareness of the technology are the key barriers that has slowed the implementation of solar energy strategies.

The power sector reform Act's energy mix, synergy of private and public sector and lack of access to electricity were revealed as the key drivers for solar energy strategies to be implemented. While economic and environmental aspects were identified as key benefits for solar energy implementation. This identification and interconnectivity of the parameters helped in the development and evaluation of a framework for adopting solar energy governance in the Nigerian power sector.

TABLE OF CONTENTS

List of Tables

List of Figures

Abbreviations and Glossary

AEO	African Economic Outlook
APC	All Progressive Congress
CA	Content Analysis
CA	Conversation Analysis
CAQDA	Computer Assisted Qualitative Data Analysis
CBN	Central Bank of Nigeria
CEOs	Chief Executive Officers
DA	Discourse Analysis
DisCo	Distribution Companies of Nigeria
ECN	Electricity Corporation of Nigeria
ECN	Energy Commission of Nigeria
EPA	Environmental Protection Agency
EPIC	Electric Power Implementation Committee
EPSRA	Electric Power Sector Reform Act
FCO	Foreign Commonwealth Office
FCT	Federal Capital Territory
FMP	Federal Ministry of Power
GDP	Gross Domestic Product
GenCo	Generation Companies of Nigeria
GHS	Green House Gases
GT	Grounded Theory
GW	Gigawatts
IPP	Independent Power Producer
JICA	Japan International Agency
KWH	Kilowatts Hour
LGA	Local Government Area
MDAs	Ministries, Departments and Agencies
MDGs	Millennium Development Goals
MW	Megawatts
NA	Not applicable
NAPTIN	National Power Training Institute of Nigeria
NBET	Nigeria Bulk Electricity Trading
NBS	National Bureau of Statistics
NCERD	National Centre for Energy Research and Development
NDA	Niger Dam Authority
NDHS	National Demographic and Health Survey
NEEDS	Nigerian Economic Empowerment and Development Strategy
NEP	National Energy Policy
NEPA	National Electric Power Authority
NERC	Nigerian Electricity Regulatory Commission
NESCO	Nigerian Electricity Supply Corporation
NESI	Nigerian Electricity Demand and Supply Industry
NIPP	National Integrated Power Projects
NMA	Nigerian Meteorological Agency

NPSG	Nigerian Political Summit Group
NREAP	National Renewable Energy Action Plans
NREEEP	National Renewable Energy and Energy Efficiency Policy
PDP	People Democratic Party
PHCN	Power Holding Company of Nigeria
PPA	Power Purchase Agreement
PV	Photovoltaic
R & D	Research and Development
RE	Renewable Energy
REA	Rural Electrification Agency
REP	Rural Electrification Policy
RIO	Return on Investment
SAS	Standalone System
SDGs	Sustainable Development Goals
SERC	Sokoto Energy Research Centre
SHP	Small Hydropower
SON	standard organisation of Nigeria
SWOT	Strength, Weakness Opportunity Treats
TA	Thematic Analysis
TCN	Transmission Company of Nigeria
TEM	Transnational Stage Electricity Market
TSP	Transmission Service Provider
TWH	Terawatts Hour
UNCTAD	United Nation Conference on Trade and Development
UNDP	United Nation Development Programme
US	United State
USAID	United State Agency for International Development
WB	World Bank
WBI	World Bank Institute
NCEEC	National Centre for Energy Efficiency and conservation
NELMCO	Nigerian Electricity Liability Management Limited
NEMSF	Nigerian Electricity Market Stabilisation Facility
REPG	Renewable Electricity Policy Guidelines
REAP	Renewable Electricity Action Programme
NBPI	Nigerian Biofuel Policy Incentive
REMP	Renewable Energy Masterplan
MYTO	Multi-year Tariff Order
REUCS	Rural Electricity User’s Cooperative Society
RESIP	Rural Electrification Strategy and Implementation Plan
FEC	Federal Executive Council
FME	Federal Ministry of Environment
KVA	Kilo-Volt -Ampere
IDB	International Development Bank
ADB	African Development Bank
FMLHUD	Federal Ministry of Land, Housing and Urban Development
GIZ	German Agency for International Cooperation

NASENI	National Agency for Science and Engineering Infrastructure
FMF	Federal Ministry of Finance
EMS	Electricity Management Services
NPC	National Planning Commission
NAEC	Nigeria Atomic Energy Commission
ICRC	Infrastructure Concession and Regulatory Commission
ICREEE	Inter-Ministerial Committee on Renewable Energy and Energy Efficiency
NCOP	National Council on Power
ISM	Interpretive Structural Modelling
EFCC	Economic and Financial Crime Commission
UNFCCC	United Nations Framework Convention on Climate Chane
SSIM	Structural Self-Interaction Matrix
SHS	Solar Home's Systems

ACKNOWLEDGEMENTS

Praise be to almighty God who guided me through this journey, gave me strength, health and determination to carry out this research work.

Firstly, I owe my profound gratitude to my family in the United Kingdom, United State of America, Nigeria, and Cameroun for the continue understanding, support, encouragement and love they have shown throughout this journey.

It would have almost impossible to reach this stage of my research without support, guidance, reminders and endless pushing for hard work from my Director of Studies (DoS) Dr Subashini Suresh, together with Dr David Oloke and Dr Suresh Renukappa, who has been providing invaluable encouragement, suggestions, criticism, advice, comments and suggestions towards achieving this research, I will say thank you all.

I would like to express my appreciation to the Petroleum Technology Development Fund (PTDF) for fully funding the PhD and other financial support and encouragement in various ways. I also appreciate the enthusiastic support of the PTDF staff throughout this journey, I am indeed grateful.

I am grateful to all the respondent and research participant throughout the data collection exercise and the subsequent correspondences for follow-up for evaluation of this research.

My profound gratitude goes to my parents, Hajiya Asia Abdullahi Machu and Late Alhaji Abdullahi Machu, for their continuous prayers, support and encouragement. A very big thank you to my lovely and beautiful wife, Bilkisu Ibrahim Mohammed and my Son Abdul-Basit Dahiru, for withstanding the inconveniences, loneliness and absence caused by this research. My appreciation also goes to my brothers and sisters; Hashimu, Abdul, Ali, Idris (late), Abubakar, Ummaru, Suleiman, Amina, Halima, Dudu and Rukayya. I am also grateful to the entire families of late Mallam Yahyah Ismail, the family of Eng. Saleh Dunoma, Aminu Shuaib Kawoje and Prof. S. Maiwada.

Finally, thanks to the wonderful people in my life; In Nigeria, Cameroun, United Kingdom and the United State of America for believing in me throughout this journey.

Thanks to the great staff of the University of Wolverhampton especially the school of architecture and Built environment, Faculty of Science and Engineering, my research colleagues and friends for their continuous support during this research.

DECLARATION

I, Dahiru Abdullahi declare that this report is my own research, and every effort has been made to clearly indicate the contribution from others by providing the appropriate references in due course to the literature sources. The report of such has not been submitted before any degree or examination in any other University or academic institution. I further declare that the research is guided by authorisation and consent as stipulated on the ethical guidance, University of Wolverhampton.

DEDICATION

This research is dedicated to my parents, Alhaji Abdullahi Machu (late) and Hajiya Asia Dande.

CHAPTER ONE

Introduction

1.0 Introduction

This chapter describes the background and the need for this study in doing so the research question is presented followed by the aim and objectives. The chapter also provides a brief methodology, scope of the study and a structure of the thesis.

1.1 Background of the Study

Nigeria is on the western coast of Africa, with diverse geography ranging from arid to humid equatorial climate. Nigeria strength is its people with diverse hundreds of languages spoken, including Hausa, Yoruba, Igbo, Tiv, Ibibio, Fula, and English (Nwankwo et al., 2018). The country has abundant natural resources such as large deposit of petroleum products, natural gas, mineral resources and energy resources (Udebunu, 2011). Nigeria lies within latitudes 4.321N and 141N and longitude 2.721E and 14.641E, with a land area of about 924,000 km^2 and a population of 194 million people (Ohunakin et al., 2015; Abila, 2016).

Most of the Nigerian citizens are rural dwellers and have limited access to electricity in their communities (Arowolo *et al*., 2019). The rural dwellers resort to the use of diesel and petrol generators, kerosene lanterns and charcoal fire flames for lighting. The method is associated with challenging factors which include high cost of fuel, scarcity of fuel and diesel generator parts (Ogbuabor, *et al*., 2018). Apart from the high cost of fuel and maintenance, other constraints include lack of access to good roads especially, during the rainy season, where some roads are flooded for several days. As a result, the transportation of fuel materials to power the generators become challenging (Ohimain and Izah, 2016).

Other options for lighting include the use of kerosene lamps, candles, and charcoal, which causes negative impact to the environment.

Nigeria is Africa's biggest oil producer and the 13th largest producer of oil in the world with daily production reaching about 2.5 million barrels a day (Udebunu, 2011). Nigeria also has the second largest proven oil reserves in Africa and the 6th largest in the world. About 90% of the country's economy are dependent on crude oil (Ohimain and Izah, 2016). The petroleum industry has been plagued by massive corruption, militancy, oil spills and oil theft, thus the industry remains the major exporter and the biggest source of foreign earnings for the country (Orji, 2014).

Nigeria has abundant of other resource reserves than crude oil such as the natural gas, this includes associated and non-associated reserves, as a result, Nigeria placed among the top 10 countries with the largest gas reserves in the world (Orji, 2014). Other resources Nigeria possesses, including 4.1 billion tons of tar sands and 1.52 billion tons of coal and lignite. However, it has been estimated that Nigeria's fossil fuels will be depleted to an uneconomical point by the year 2050, going by the present extraction trend (Akuru and Okoro, 2011). Although Nigeria is an oil and gas rich country, more than 70% of its petroleum product requirements are imported from other countries because the local refining infrastructure are dilapidated and obsolete (Osinowo *et al*., 2015).

Nigeria has potential for renewable energy source such as wind, solar, biomass and hydropower (Osinowo *et al*., 2015). Hydropower has the utmost renewable energy potential, which amounts to 10,000 MW of large hydropower and 734 MW of small hydropower (SHP) (Ikpe and Torriti, 2018). Wind energy with a potential of 150,000 terra joules per year, can generate an average wind speed of 2. 0–4. 0 m/s. Solar radiation

estimated at 3.5–7.0 kWh/m2, and biomass at 144 million tons per year (Olomiyesan and Oyedum, 2016).

Solar energy can provide a cheap and abundant energy for communities whose connection to the national grid may not be economical viable due to their remote physical location from the nearest grid connection point (Umoh and Lugga, 2019). Solar energy can be an alternative source of energy in rural and remote areas of Nigeria. It complements the rapid development of small-scale industries and reduces the rural–urban drift. The country receives abundant solar radiation and sunshine (Akuru and Okoro, 2011). Solar energy is the most promising among the renewable energy resources in Nigeria due to its apparent abundance (Olomiyesan and Oyedum, 2016). There is abundant solar energy radiation and land for solar development in Nigeria. The solar energy radiated from the sun is about 3. $8*10^{23}$ kW, which is 1.082 million tons of oil equivalent per day (Olomiyesan and Oyedum, 2016). This is about 4000 times the current daily crude oil production in Nigeria and about 13,000 times the natural gas daily production, based on standard energy units (Osinowo et al., 2015). Nigeria can generate its electricity for the entire country by using one percent (1%) of its land (Ohimain and Izah, 2016). Nigeria has an average of 1. $804*10^{15}$ kWh of incident solar energy annually based on Nigeria land area of $924*10^3$ km^2 and an average of 5.535 kWh/m^2 per day on the average, the sun shines for 6.5 h/day (Ohimain and Izah, 2016). The annual solar energy value is about 27 times the country's total fossil in energy units and is over 115,000 times the electricity produced (Abila, 2016). Therefore, about 3.7% of Nigeria’s landed area is required to collect an amount of solar energy equal to the country's conventional energy reserves. In spite of the availability of solar energy, there is a need to explore how solar energy strategies can be implemented along with the current power sector reforms.

1.2 Problem Statement

There is an increasingly growing concern of daily epileptic power supply experience in Nigeria (Oyedepo, 2012). Individuals, households, and organisations burn up more fossil fuels, thus leading to high cost of living, high cost of business operations, increase in the cost of goods and services, and increases greenhouse gases which are detrimental to the environment and health (Ozughalu *et al*., 2019). The intermittent power outage in the country has costs Nigeria an estimate of $29 billion a year (IMF), thus, affect other areas of productivities, including foreign direct investment (Nwosa, 2018).

Nigerian electricity outage has been a problem for over a century despite the vast amount of renewable and non-renewable energy deposits in the country (Aigbovo and Ogboka, 2016). Nigeria is placed as one of the poorest in the world in terms of energy production as per-capita on-grid electricity consumption stands at 126 kWh, which is far less than South Africa (3926 kWh) and Ghana (362 kWh) (Olomiyesan and Oyedum, 2016).

The under-utilisation of the installed generating capacity can be attributed to poor management of the power grid facilities, which retain high energy losses, between 30% and 35%, from generation to billing (Monyei, et al. 2018). This is significantly high as compared with the US, where power losses across lines usually come to less than 7%, even across long distances (Oyedepo, 2014).

In addition, there is a low collection rate between 75–80%, and low access to electricity by the population, thus affecting the revenue of the body that oversees the operation of power in Nigeria (Aigbovo and Ogboka, 2016).The Power Holding Company of Nigeria (PHCN) as the body that regulate the operation of the power sector, is consequently reliant on fuel subsidies and state funding of capital projects (‘‘Power supply to Nigerian households

declined in Q2 – Poll,'' 2019). Declining electricity generation from several domestic power plants has sent the country into an energy crisis (Oyedepo, 2014).

It is estimated that nearly 70% of the Nigerian population have no access to electricity and only about 25% of the electricity generated is delivered to the end-users, whilst the remaining 75% is lost between generation and transmission process (Umoh and Lugga, 2019). As a result, expensive device for electricity generation has to be adopted to meet both household and industrial demand which has impact on end user's (Ozoegwu *et al*., 2017).

The country's current power generation capacity is just above 12,000 MW installed, but often electricity generated and transmitted is between 3,500 MW/h to 4,000 MW/h (Emodi, 2016). The population of the country is increasing at a geometric rate and it is estimated that by 2050 Nigeria will surpass USA and thus, the demand for electricity will double or triple and the situation can be more challenging as the infrastructure has failed to meet current demand for Nigeria economic development (Edomah, Foulds and Jones, 2017).

Even though, the federal government saw the need for diversifying the power sector into the energy mix, including solar energy, the implementation process is far slower as literature reviews could not trace a significant progress (Ozoegwu *et al*., 2017; REA, 2018). Solar energy, wind energy and mini grid are developing within the Nigerian energy market in which solar energy plays the lion's share across all regions (Elum and Mjimba, 2020). The current solar energy deployment in Nigeria is relatively insignificant compared with that of South Africa's, which already have more than 200,000 'off grid' installations of PV while Nigeria is at its early-stage development (Ogunmodimu and Okoroigwe, 2019).

The Nigerian power demand and supply gap is estimated to be more than 76% as of 2016 (Mohammed *et al*., 2020). The stakeholders paid little or no attention for the opportunity to harness renewable energy resources, especially solar energy to help the power sector to minimise the demand and supply gap (Ochonogor and gbue, 2017). Solar energy development in Nigeria is faced with lack of enabling vision and mission for technology, fine-tuning and promoting the initiative (Tambari, Dioha and Failler, 2020). Although, the country has opportunities for solar radiation potentials, the market is still immature and the turnout for utilisation is low (Adesanya and Schelly, 2019). The Power Sector Reform Act. 2005 is a forward step to the Nigerian power sector uprising from conventional electricity to the energy mix. However, there is a need to speed the energy strategies to be able to achieve the EPSRA (2005) objectives and increase access to energy mix. Therefore, this research addresses to bridge the gap by empirically exploring the implementation of solar energy.

1.3 Aim and Objectives of the Research

The aim of the research is to facilitate the governance for implementing solar energy in Nigeria. To achieve this aim, the following measurable objectives have been developed:

1. To explore the Nigerian power sector reforms, challenges, and renewable energy options with emphasis on solar energy and its status in Nigeria.
2. To investigate the key drivers, key barriers, key benefits of implementing solar energy in Nigeria.
3. To develop a framework to facilitate the adoption of solar energy governance in Nigeria.
4. To evaluate the developed framework with relevant solar energy stakeholders.

1.4 Research Methodology

To answer the fundamental research question posed, a qualitative research approach based on the interpretive paradigm was adopted. A qualitative research approach allows one to have an in-depth investigation into a phenomenon to answer questions (Creswell, 2013).

To have an in-depth understanding of power sector along with the key driving factors, key barriers and key benefits of solar energy a qualitative research approach was adopted to allow the researcher to investigate the phenomenon of solar energy adoption (Rosenthal, 2016). Face-to-face semi-structured interviews were conducted. Twenty-five top executives, including directors, deputy directors, executive directors, national coordinators, managers, head of departments, a top official in energy national projects and its related financial sector organisations were interviewed. Interviews were recorded, transcribed and analysed using conventional content analysis (Dumay and Cai, 2015). Interpretive structural modelling (ISM) was further used to find the inter relationship between the key barriers for a solar energy implementation to provide fundamental understanding of the complex situation (Sarhan *et al*., 2019).

Based on the review of literature and findings from the semi-structured interviews a framework was developed and evaluated to facilitate the governance of solar energy implementation in Nigeria.

1.5 Scope of the Study

The federal government, Ministries, Departments and Agencies (MDAs) who are key players for the actualisation of the Power Sector Reform Act of 2005 and the Nigerian home groom strategies for Sustainable Development Goal (SDGs): Affordable and clean energy participated in this study. These are the stakeholders in the Nigerian power sector who

saddle the formulation of strategies, policies, promotion, and implementation of solar energy initiatives. Therefore, the scope of this study is for facilitating governance for implementing solar energy in Nigeria.

The research study is exclusively exploratory in nature and the inductive approach of methodology is adopted to answer research questions rather than testing hypothesis. Thus, the research covers both public and private sector participation in the solar energy implementation, the study did not cover other energy mix potential in Nigeria.

1.6 Structure of Thesis

This thesis is structured into nine chapters in line with the research aim and objectives of the subject-matter.

Chapter 1: Introduction of the Study

The chapter presents the background of the study, problem statement, research aim and objectives, research methodology, scope and the order in which the chapters are presented.

Chapter 2: Literature Review on the Nigerian Power Sector

This chapter explores an overview of the Nigeria power sector history, reforms, challenges, and status. The chapter discusses renewable energy options, insight of the Nigerian Electricity Demand and Supply Industry (NESI) in terms of energy access issues, generation, transmission, distribution, and gives a historical overview of the transition of the privatisation process of the power holding company of Nigeria to the power sector reform Act of 2005. In addition, the need for solar energy strategy in the country has been discussed. The chapter addressed the research objective one thorough literature review.

Chapter 3: Literature Review on Solar Energy Status in Nigeria

Reviews the relevant literatures on solar energy industry, lessons from other countries, solar energy initiative in Nigeria. Status of solar energy development in Nigeria, factors driving the need for solar energy and the barriers that challenged the solar energy implementation process. The chapter addressed objective two of the research, thorough literature review.

Chapter 4: Research Methodology

The chapter discusses the research methodology adopted, data collection methods, techniques, data analysis and interpretation and the findings from the empirical results. The chapter focuses data analysed using the conventional content analysis and interpretive structure modelling (ISM). The chapter addressed how the methods were used for the study objectives.

Chapter 5: The Nigerian Power Sector Challenges

In this chapter, the collected data about the challenges and reforms in the Nigerian power sector were analysed by content analysis and the chapter addressed objective one of this research study.

Chapter 6: Key drivers for solar energy implementation in Nigeria

The chapter focuses on data analysis from the field data on the driving factors for solar energy strategy in Nigeria. The chapter encompasses the perceived element to why Nigeria needs solar energy initiates and addressed the research objective two of the research.

Chapter 7: Key barriers and key benefits for solar energy

The chapter identifies barriers of solar energy implementation over a long period of time. The chapter also proffers strategic mitigation options to address the barriers. The key

benefits and the beneficiaries for solar energy strategy in Nigeria is also discussed in the chapter. The chapter addressed objective two of the research.

Chapter 8: Framework to facilitate the adoption of solar energy governance in the Nigerian power sector.

The chapter integrated the research findings into a research framework and evaluated the framework from the Nigerian power sector stakeholders to ascertain the usefulness, viability, and importance of the framework. The chapter addressed the research objective three and four of the research.

Chapter 9: Conclusion and Recommendations

The chapter is the research conclusion, Recommendations and Further Work which addressed the aim. The chapter concludes the findings, contribution to knowledge, recommendation for the Nigerian power sector stakeholders, researchers, and future work.

CHAPTER TWO

An Overview of the Nigerian Power Sector

2.0 Introduction

In this chapter, an in-depth review of known literature on the Nigerian power sector reforms, including the privatisation process of the power holding company (PHCN). The chapter is divided into four sections: The Nigerian power sector reforms, the challenges of the power sector and the opportunity for renewable energy sources. The literature review is aimed not just to have a thorough understanding of the Nigerian power sector and renewable energy sources, but also to address the objective one through literature review.

2.1 Reforms of the Nigerian Power Sector

The Federal Republic of Nigeria is a federal constitutional republic comprising thirty-six states and the Federal Capital Territory, Abuja. The country is in West Africa and shares land borders with the Republic of Benin in the west, Chad and Cameroon in the east, and Niger in the north. Its Atlantic coast runs along the Gulf of Guinea, in the south. Nigeria gained independence from Britain in October 1960 and became a republic in October 1963 with different administrative structures (Oduntan, 2018). Following decades of political instability and military interventions, the country adopted a new constitution and returned to a democratic system of government in 1999. The country is presently grouped into six geopolitical zones: North-West, North-East, North-Central, South-East, South-South and South-West, made up of 36 states plus the Federal Capital Territory (FCT) Abuja and has 774 local government areas (LGAs) (Oduntan, 2018). Thus, Nigeria runs a federal system with 3 tiers of government: federal, state and local government (CBN, 2015). According to Oyewo et al., (2018) the history of electricity production in Nigeria dates to 1896 when

electricity was first produced in Lagos, fifteen years after its introduction in the United Kingdom. The total capacity of the generators used then was 60 KW.

Table 2.1 Nigerian electricity development (1898 – 2019).

S/N	Period	Development activities
1	1896	Electricity was first installed. Power generation began in Marina Lagos Nigeria
2	1929	Nigerian Electricity Supply Corporation (NESCO) started operation with the construction of a hydro power station at Kuru Plateau Jos, Nigeria.
3	1951	Electricity Corporation of Nigeria (ECN) was a central body created to regulate coal and diesel plants throughout Nigeria.
4	1956	With the increase in demand for electricity, project such as Ijora in Lagos, Oji in Enugu, Kano and Ibadan were commissioned for expansion purpose.
5	1962	Niger Dam Authority (NDA) and Kainji Dam was completed in 1968, while the first 132 KV line between Lagos and Ibadan was constructed
6	1972	ECN and NDA were integrated to form the National Electric Power Authority (NEPA), for generation, transmission, distribution and marketing to consumers solely owned by the Nigerian Government.
7	1968-1990	The Four major stations: Kainji Hydro, Ijora, Afam, and Delta stations were established to operate with full responsibility for power supply.
8	1998	IPPs came on board and the NEPA high-class monopoly of generation, transmission, distribution and marketing was sculpted down.
9	2000	Electric Power Implementation Committee (EPIC) was set up to advocate privatisation including a full report to National Council on Privatisation.
10	2001	Out of the report submitted by NCP, the National Electric Power Policy was born based on the recommendation of the EPIC.
11	2004	NEPA installed a capacity of 5,906 MW, but only generate 3,400 MW due to several issues within the sector. It was therefore necessary to call for a reform
12	2005	The Electric Power Sector Reform Act (EPSRA) was enacted to unbundle and restructure the Nigerian power sector. The Nigerian Electricity Regulatory Commission (NERC) was established to regulate the electric power and tariff in the sector. Rural Electrification Agency (REA) was established. Nigerian Electric Power Authority (NEPA) was unbundled into six (6) generating companies, one (1) transmission company and Eleven (11) distribution companies.
13	2009	National Power Training Institute of Nigeria (NAPTIN) was established and Rural Electrification Policy (REP) was also approved to work with REA.
14	2010	Roadmap for power sector Reform was launched as policy documents to help the restructuring of PHCN.
15	2012	PHCN was liquidated which relinquished 70% of ownership shares to generation and distribution private companies and retained the ownership of the transmission company.
16	2013	The successfully privatised generation and distribution was handed over to the successor private owners known as GenCos and DisCos.
17	2014	Strengthening of renewable energy programs and seven out of ten NIPP generation asset sales are completed.
18	2015	Power Purchase Agreement (PPA) were established, Transnational Stage Electricity Market (TEM) satisfied by the NERC. The TCN Independence System Operator was made public. National Renewable Energy and Energy Efficiency Policy (NREEEP) were approved to drive the power sector reform.
19	2016	Draft for Mini-Grids operation approved (NERC, 2016). National Renewable Energy Action Plans (NREAP) approved (NREAP, 2016).
20	2019	Nigeria and Siemens Draw Up Roadmap to Boost Country's Power Supply sign by the Nigerian President 2019.

Source: Abam, et al. (2014); Aliyu, et al. (2015); Emodi and Yusuf (2015); ECN (2018); Oladipo et al., (2018); NERC (2019); Arowolo and Perez, (2020).

From the table, above, it is evident that the Nigerian Electricity developed gradually under different phases aimed at improving the supply of the electricity to meet the demand of the Nigerian population (Aliyu, *et al*. 2015). The inability to generate, transmit and distribute adequate electricity to maximum capacity has resulted in crippling the commercial industries. Individuals and various organisations depend heavily on self-generated electricity from generators (Gujba, *et al*. 2011), thus increasing operational cost, increase on Co_2 emission, poor quality of life, etc.

2.1.1 Nigerian Electric Power Sector Reform Act (NEPSRA, 2005)

The Nigerian electric power sector has been experiencing an enormous transformation for years with an effort to pull together strategies towards achieving stable power supply through generation, transmission and distribution projects as part of the Federal Government Economic Reforms (Oyedepo, 2014). Although, the expansion plans indicate that the power sector will undergo significant changes soon to achieve the vision 20:20 as indicated in (table 2.3) and this is further expected to increase almost four times by the year 2030 to accomplish the Independent Power Producer (IPP) plans (Aliyu, *et al*. 2015).

Oyedepo, (2014) argued that the current situation of the Nigerian power sector is dilapidated, as 70-80% of the powers, generated are thermal and 20-30% are hydroelectric, though, only about 40-51 % of Nigerians have access to electricity and only 18% of the rural dwellers have access to electricity. In other words, those who are connected to the national grid face extensive power interruption throughout the year (Ikeme and Ebohon, 2005). As shown in table 2.4, the total capacity generated before 2012 was only 2,030 MW to serve 160, million Nigerians (Gatugel, *et al*. 2015). It was, therefore, apparent for the

government to showcase alternative plans to boost electricity by reinvesting more on large hydroelectric plants as well as diversifying to energy mix (Aliyu *et al*., 2013).

2.1.2 Deregulation of the Electricity Industry

According to Amobi (2007), the structure of the Nigerian Power Sector is made up of 3 major subsectors as depicted below:

1. Generation
2. Transmission
3. Distribution

In 2005, the Nigerian Government raised concerns over compelling issues, principally; power outages, unreliable services, unrealistic bills and many other issues emerged for need of action to enact the Electric Power Sector Reform Act of 2005 (Airoboman *et al*., 2017). The act called for unbundling the National Power Utility Company into a series of six generating companies, twelve distribution companies while retaining the ownership and management of the transmission company to the Federal Government of Nigeria (Adebayo *et al*., 2020). Eve though, the reform was aimed at finding a solution to the long experiences of inadequate electric power supply in Nigeria, there was little indication in the reform to diversifying into renewable energy projects as support for the Independent Power Producers (IPP) (Amobi, 2007). The next three sections discuss the outcome of the privatisation and unbundling the defunct Power Holding Company of Nigeria (PHCN) into generation, transmission and distribution companies of Nigeria.

2.1.3 Generation Company of Nigeria (GenCo)

The generation company of Nigeria, popularly known as GENCO was the first company among the three born out of PHCN to be found as part of the IPP to a private company (Gujba *et al*., 2011). Thus, the Nigerian Electricity Supply Industry (NESI) processed 23 grid-connected generating plans with total capacity of 10, 396.0 MW, in which, the available capacity at the time of this exercise was to be 6, 056 MW. However, among the installed capacity, the mainstream of the generation is a thermal power plant with total installed capacity of 8, 457 MW (81%) and available capacity of 4, 996 MW (83%) (Gujba *et al*., 2011). Emodi and Yusuf (2015), further emphasised that, hydropower from the three (3) plants account for 1, 938.4 MW, of which 1, 060 MW, is the available for transmission.

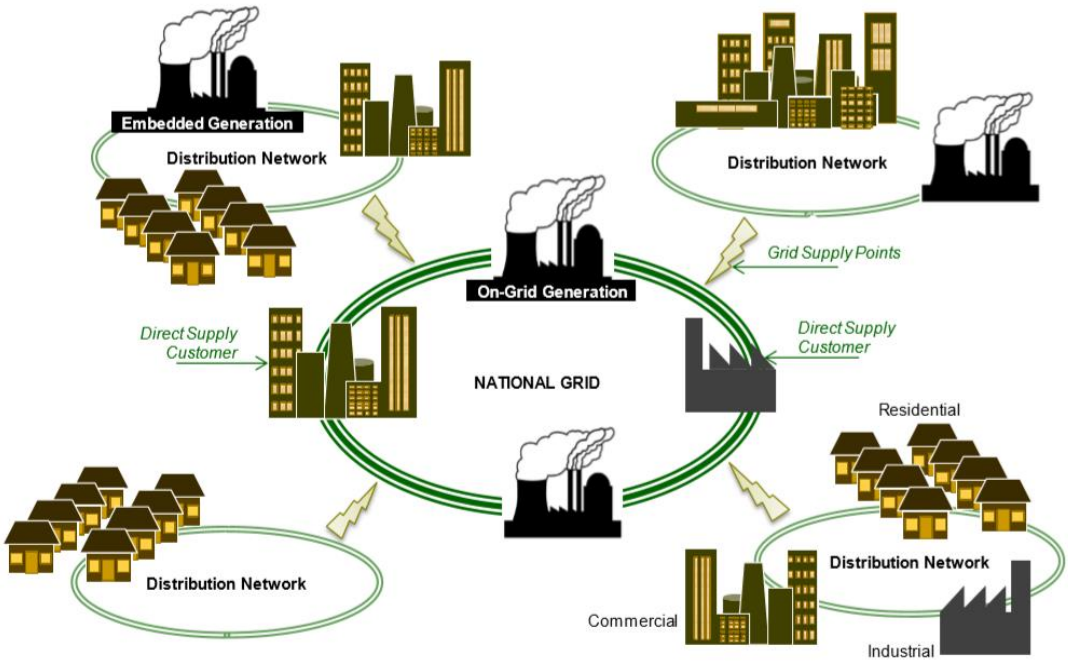

Figure 2.1 Embedded and On-Grid Electricity Generation

Source: ECN (2016)

Figure 2.1 above detailed the Nigerian national grid as embedded generation, transmission and distribution network of electricity sources across the country. The next table shows the Initial NIPPs after the power holding company of Nigeria (PHCN) was privatised.

Table 2.2 Purchasers of Successor GenCos

S/N	Successor GenCos	Purchaser	Bid (US$ mm	Stake Acquired	Capacity (MW)
1	Afam Power	Televeras Energy Group	260.1	60%	776
2	Egbin Power	NEDC/KEPCO Consortium	407.3	70%	1,320
3	Geregu Power	Amperion Power Distribution Co. Ltd	132.0	51%	414
4	Kainji Hydro Electric	Mainstream Energy Solution Ltd	237.9	A 15 Year Concession	760
5	Sapele Power	CMEC/EURAFIC Energy Consortium	201.0	100%	1,020
6	Shiroro Hydro Electric	North South Power Consortium	111.7	A 15 Year Concession	600
7	Ugheli Power	Transcorp Consortium	300.0	100	942

Source: ECN (2016); NERC (2014)

The table above shows that, the NIPP can generate up to 5, 832 MW of electricity for the six geopolitical zones in Nigeria. Although, the amount of MW that is available for the TCN to distribute to Discos centres cannot be quantified due to loss of electricity on transmission lines (Emodi and Yusuf, 2015).

2.1.4 Transmission Company of Nigeria (TCN)

The transmission Company of Nigeria (TCN) is one of the successors of the PHCN, after the unbundling of the power sector. Though, the TCN remains the only company that was not privatised during the privatisation process of PHCN (Adebayo *et al*., 2020). The federal government of Nigeria contracted the TCN to a Canadian firm; Manitoba Hydro International (Canada) whose major responsibility, among others, is to ensure market operator (MO), the system operator (SO) and Transmission Service Provider (TSP) become autonomous (Adebayo *et al*., 2020). The TCN holds the PHCN grid assets and manages it

on behalf of the Nigerian government. The next paragraph will discuss the power purchase agreement guarantor:

2.1.5 Nigerian Bulk Electricity Trading (NBET)

Nigerian Bulk Electricity Trading (NBET) is the administrator of the Nigerian Electricity Supply Industry (NESI) which is a 100% Nigerian government owned to guarantee the fulfilment of the roadmap of the Power Sector Reform Act. (EPSRA) (Odubiyi and Davidson, 2002). NBET is a financial intermediary between the IPPs of GenCos and DisCos through the TCN and settle all financial disputes when they arise. The next diagram will show the interconnectivity transitional Electricity Market (TEM). One of NBET roles is to act as a broker between power producers and the DisCos until the market is mature enough to support commercial bi-lateral trading (Ahmed, 2020).

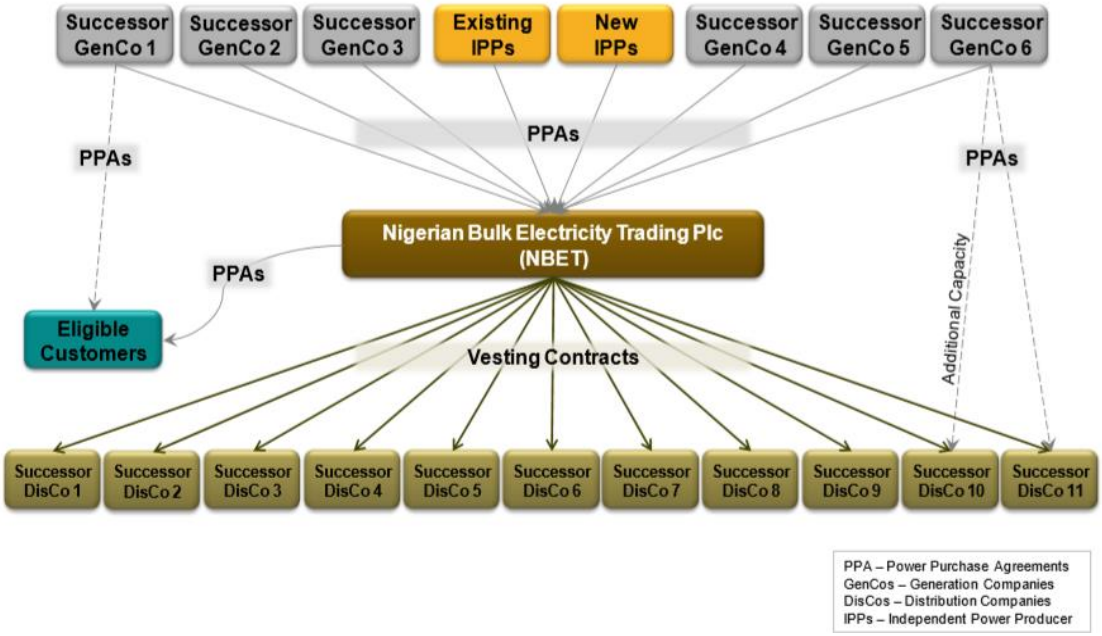

Figure 2.2 Transitional electricity market (TEM) Trading arrangement

Source: ***ECN (2016)***

NBET is saddled with responsibilities of signing the PPAs, resell power view vesting to DisCos, negotiate with new PPAs and act as the Nigerian government institution guarantee provider.

2.1.6 Distribution Company of Nigeria (DisCo)

The Nigerian Distribution Company (DisCo) was born out of the Nigerian Power sector reform proposed in 2005, through 2013 and beyond (Ahmed, 2020). As part of the privatisation exercise, the Power Holding Company of Nigeria's (PHCN) distribution was unbundled into eleven (11) regional grids, which were acquired by private local and foreign investors (Transmission Plans, 2013). Each Disco's is allocated a certain amount of grid energy even though the amount of grid varies in quantity to match the demographic population demand (Ahmed, 2020). The DisCos are faced with numerous challenges, including distribution losses, technical difficulties, and commercial and billing system. Technical barriers caused a loss of (12%), commercial (6%) and collection of revenues (28%) respectively (Edomah *et al*., 2016). The table below shows the DisCos exercises.

Table 2.3: Purchasers Distribution Companies of Nigeria (DisCos)

S/N	Successor GenCos	Purchaser	Bid (US$ mn	Stake Acquired	Capacity (MW)
1	Abuja DisCo	KANN Consortium Utility Co. Ltd	164.0	60%	1,802
2	Benin DisCo	Vigio Power Consortium	129.0	60%	1,855
3	Eko DisCo	West Power & Gas Consortium	135.0	60%	1,440
4	Enugu DisCo	Interstate Electric Consortium	126.0	60%	1,920
5	Ibadan DisCo	Integrated Energy Distribution and Marketing	169.0	60%	1,989
6	Ikeja DisCo	NEDC/KEPCO Consortium	131.0	60%	2.077
7	Jos DisCo	Aura Energy Ltd	82.0	60%	714
8	Kaduna DisCo	Northwest Power Ltd	201.0	60%	1,233
9	Kano DisCo	Sahelian Power SPV Consortium	137.0	60%	788
10	Port Harcourt DisCo	4Power Consortium	124.2	60%	1,164
11	Yola DisCo	Integrated Energy Distribution and Marketing	59.3	60%	265

Source: Arowolo, et al., (2019)

The Nigerian Government made efforts to establish reforms over the years to tackle the decaying electricity infrastructure from the generation, transmission and for distribution (Adebayo *et al*., 2020). However, the reforms are basically conventional and therefore, not far from the old systems of fossil fuel. The table below is a comparison for generated electricity versus population growth.

Table 2.4 Installed and available power generation versus Nigerian population

Year	Installed Capacity (MW)	Available power (MW)	Population (Million)
1980	2507	783	73.7
1985	4192	1133	83.9
1990	4548	1537	95.6
1995	4548	1810	108
2000	5580	1738	122.9
2005	6538	2494	139.6
2010	6904	3358	159.7
2014	8876	3795	177
2016	13761	4285	184
2018	13761	4000	195.8

Source: World Bank, (2014); Oyedepo, (2014)

The table above presented an electricity installation versus the population growth in Nigeria. It is not a surprise with the electricity outage in recent years as the population grows significantly, the megawatts capacity deteriorated between 2016 and 2018.

The power sector is therefore in need of urgent attention to consider more reliable energy options to reinstate the crumbling of the fastest growing economy in Africa especially Nigeria (Bugaje, 2006; Akuru *et al*., 20017).

The Power Sector Reform Act of 2005 proposed in 2003 and the privatisation and transfer of ownership were finally established in 2013 excepting the transmission company of Nigeria (TCN) which remains the federal government entity (Alao and Awodele, 2018).

The TCN is managed by a Canadian consulting firm Manitoba Hydro International to strengthen the transmission and revamping of the power as part of the EPSRA objective.

The TCN transmission capacity systems stand about 5,523.8km of 330 KV lines and 6,801.49 km of 132KV lines (Arowolo *et al*., 2019). Although, Nigeria has the potential to generate more than 12,522 megawatts (MW) of electricity from all sources (Jacob and Abubakar, 2005). The most generated capacity is about 4000 MW, of which a significant amount is lost in transmission from theft, obsolete facilities and vandals which result in a total generation below 2,700 MW. This is far below the peak forecast of 8,900 MW for the existing infrastructure and inadequate for a country of over 200 million people (Adedokun, 2015).

2.2 Nigerian Power Sector Challenges

The Nigerian power sector has faced massive challenges over a long period of time. These challenges include the history of massive corruption practices that led to the downturn of the power sector development. literatures have emerged that corruption is the result for the constrain of socio-economic development in the country over the last two decades (Sambo *et al*., 2012). Although, literature defined corruption as ‘‘abuse of entrusted power for a private gain’’, the corrosive impact of economic development in Nigeria and Sub-Sahara African countries within the power sector has resulted to risk of uncertainty in investment (Obuah, 2010). Literature established that Nigerian power sector is a gas dominated grid and frequent collapse of the supply of electricity is linked to inadequate supply of gas to the grid plants (Gatugel *et al*., 2015). Lack of maintenance of the grid infrastructure is also associated with the power failure as some of the plant equipment have become obsolete and no longer operational (Alao and Awodele, 2018). The Nigerian government has endeavoured to address these challenges, reduce energy poverty and increase electricity

efficiency by introducing energy options of the Power Sector Reform Act 2005 (Imam, Jamasb and Llorca, 2019).

The Corruption Perception Index (CPI) produced by the Transparency International in 2013 shows that, eight of the twenty most corrupt countries in the world, were obviously Sub-Sahara African Countries (Ikoh, 2018). Surprisingly, they were more than two countries with high corruption rate in the same continent. However, there is no research evidence of empirical study available on power sector reforms and solar energy implementation, as such this study will explore the Power sector challenges and reforms in chapter five (Ijewereme, 2015). The next section will discuss renewable energy development as part of the power sector reform Act 2005.

2.3 Renewable Energy Development

Ang et al., (2015) defines renewable energy as a form of energy that is obtained from inexhaustible sources such as solar, wind and geothermal. Bugaje (2006) defines renewable energy as any form of energy that is produced from natural resources such as sunlight, water, wind, geothermal heat, biofuels, and biogas. Renewable energies are generated from natural resource with technology assisted initiatives (Verbruggen *et al*., 2010). The techniques are constantly replenished by nature with different features that determine the means of generation and capacity. Renewable energy sources are preferable because they have no negative impacts on the environment and are sustainable source compared to nonrenewable energy sources. Nonetheless, renewable energy sources require sophisticated technologies to harness the energy for immediate use and to store the surplus for later usage (Twidell and Weir, 2015).

Solar energy is considered as an exhaustive source of energy that required no extra cost for maintenance to strive its full potential. Among all the renewable energy sources, solar energy is the most convenient to harness as compared to wind and geothermal power, because solar can be generated near to where it is consumed. Nevertheless, solar power poses a significant challenge in winter countries because there are only four months of adequate solar energy (Akinyemi *et al*., 2012). In Nigeria, however, there is enough sunshine potential for solar energy throughout the year, which can be harnessed to supply sustainable and stable electricity.

Solar energy is one of the clean energy technologies designated as the most promising in terms of its apparent limitless potentials among the energy mix (Emodi and Boo, 2015). Solar energy is a powerful energy sourced from the sunlight radiation that is harnessed using modern technology such as PV, thermal, heating, and other photosynthesis to generate, store and used for electricity (Riti and Shu, 2016). This type of energy is considered as cheap in terms of affordability, but it is also environmentally friendly, easy access and can assist both domestic and commercial uses. Oyedepo (2014) stressed that solar energy is a safe energy option for small scale industries for rural community development. Nigeria is blessed, to be placed within a sunshine belt in the Sub-Sahara African region. Nigeria is therefore potentially having the opportunity to generate most of its power source from solar to eradicate the frequent power supply outage (Aliyu, et al. 2015).

Despite the long-dilapidated condition of power supply in Nigeria, renewable energy such as solar, has not received a significant attention either by the government or private sector (Nwokocha *et al*., 2018). It is estimated average distribution for solar radiation amount to 19.8MJm^{-2} day $^{-1}$ with an average sunshine of six to seven hours per day. If this solar energy were potentially harnessed, Nigeria could generate 1850 x 10^3 GHh of solar electricity per

year (Riti and Shu, 2016). They further argued Nigerian Energy Commission and the Nigerian Electricity Regulatory Commission are working together to ensure high supervision of proposed projects such as the energy research centres are monitored and working to achieve a positive result. The existing solar projects include several PV-water pumping, Solar thermal and electrification for cooking, incubators, rural clinics refrigerators, traffic lighting and road signs across the geopolitical zones.

Literature (Wold Economic Forum, 2013; Twidell and Weir, 2015; Riti and Shu, 2016; and Somefun *et al*., 2020) revealed that Solar energy has more potentials and least disadvantages among the available options of renewable energy sources in Nigeria. Aliyu *et al*., (2015) argued that Nigeria conventional electricity has failed for many years and the impact on socio-economic development in the country cannot be over emphasised. However, the power sector reform Act of 2005 suggested that the country's energy system be privatised and integrated into energy options (Osinowo *et al*., 2015). Although, there are literatures on the Nigerian power sector challenges, reforms, and the way forward, current research on the power sector challenges beyond 2014 and modern mitigation strategies to tackle the underpinning challenges remains unexplored. Therefore, the next chapter explores the solar energy aspects.

2.4 Summary of the Chapter

In this chapter, the research objective one is addressed, which critically looks deep into the Nigerian power sector background, history, status, reforms, and the transition of the PHCN during the privatisation process. The chapter has also looked at the Nigerian electricity generation, transmission, and distribution versus the population growth where it is determined that the power sector has not delivered its full capacity potential. Although, the infrastructure capacity can generate just above 12,000 MW of electricity, the distribution

capacity has only reached a peak of 7000 MW in 2019. This capacity is unable to reach 70% of the Nigerian population, especially in the rural areas where grid connection is yet to be deployed. In addition, the potential renewable and solar energy initiatives as part of the power sector reform Act strategy for sustainable electricity in Nigeria has discussed. The next chapter will discuss solar energy potential in Nigeria, the current status of the solar projects, key factors driving the potential for the initiatives, barriers that are hindering the implementation process.

CHAPTER THREE

Adoption of Solar Energy Governance in Nigeria

3.0 Introduction

In this chapter, an in-depth literature on solar energy background, solar energy status, potential opportunities, lessons learnt from other countries, solar energy drivers, barriers and mitigation options, key benefits and the beneficiaries of solar energy initiatives are discussed.

Solar energy is the process of exploiting radiant energy emitted by sunlight for electricity (Twidell and Weir, 2015). Solar radiation is converted to energy in so many ways, but the most common two are the photovoltaic (PV) which is done by direct method and the indirect method (thermal) where the sun is harnessed to boil and heat water which is converted to energy (Tyagi *et al*., 2013). Solar energy is one of the highest renewable energy adopted by many countries in recent years (Tyagi *et al*., 2013). Nigeria is in its earliest stage for solar energy development, as a result, the country is ranked among the lowest electricity generation and distribution in Africa (UNDP/SDGs, 2015). Nigeria is the most populous nation in Africa and the 7th most populous country in the world, potentially has the capacity to achieve the United Nation Sustainable Development Goals (SDGs) by 2030 (Giwa *et al*., 2017).

3.1 History of Solar Energy

Before the discovery that the sun's light could be collected and converted into electricity. Passive designs were used to take advantage of the climate to maintain a comfortable temperature in buildings (Szabó and Kalmár, 2019). Passive design reduces or eliminates the need for auxiliary heating or cooling and has been used by civilisations for millennia.

Ancient Greeks, Egyptians and Native Americans built homes and cities to have the most energy efficient sun exposure (Mainzer *et al*., 2016).

Greek and Roman architecture developed with solar energy in minds for many years. Porticos – series of thick and evenly spaced pillars – were built in order to let the sunlight filter through. This allowed for the right amount of light and heat to come through. In Ancient Egypt, black tile-lined pools of water collected solar energy throughout the day (Sinclair, 2014). At night, water would be used to keep palaces, warm through the heated pipes. It wasn't until the 19th century that we began turning the sun's light into electrical energy. In 1839, French Physicist Alexandre Edmond Becquerel discovered the photovoltaic (PV) effect (Wood, 2016). The PV effect is the creation of electric charge as the result of exposure to light through the stimulation of electrons in metals such as selenium or platinum as conductors.

Aleksandr Stoletov developed the first solar cell based on the photoelectric effect in the late 19th century. The industry didn't begin to grow, however, until the development of a silicon-based solar cell by Bell Labs in the 1950s (Izquierdo, *et al*., 2014). The development of individual solar cells led to the manufacture of panels, which are a collection of solar cells. Solar panels are the optimal surfaces to capture the light. Throughout the 1950s, the efficiency of solar cells kept on increasing, from 8% in 1957 to 14% in 1960 (Heller, 2015). The space race created a need for sustainable energy sources. It is steered investments and development in the solar industry. In the 1960s, the first telecommunication satellite TelStar 1 launched by Bell Labs featured the most cutting-edge solar cells (Heller, 2015).

Despite the advance achievement made in solar energy technology, it is not commercially viable yet due to the high cost of initial installation (Somefun *et al*., 2020). The initial push

to lower the cost of solar energy came from oil companies who recognises the future financial difficulty for sustaining energy production with oil and Gas (Ozughalu *et al*., 2019). Therefore, saw the need for a back-up option plan which drives the companies into investment and development in solar energy. Backed by Exxon, Dr. Elliott Berman designed a much less expensive solar cell. He brought the cost per watt down by 80%. Since 2008, solar power has become increasingly popular as its price became affordable to a much wider market (Bhandari and Stadler, 2015). Research and investment in solar energy technology continue to strive in an energetic pace with a passion for sustainability and fighting the global warming effect. Solar manufacturers continue to pursue technological improvements to make solar panels more efficient, more effective and less expensive (Smets, 2016).

3.2 Type of Solar Energy

Solar energy comprises of two major technologies known as Photovoltaic (PV) and Thermal. The PV which is directly converting the sun into electricity and thermal is harnessing heat, store to convert to electricity energy either in small or large quantity (Emetere and Akinyemi, 2016). The two technologies are further discussed in detail.

3.2.1 Solar Photovoltaic (PV) in Nigeria

Nigeria is blessed with abundance of solar radiation throughout the year, especially the northern part of the country. Although, there is huge potential for solar irradiation across the country, the amount of electricity that can be harnessed through the initiatives is yet to be quantified. However, it is estimated that Nigeria needs only one percent (1%) of its land to build solar farms capable of powering the entire country (Bamisile *et al*., 2020). Nevertheless, most opportunities are challenging with barriers and Nigeria lacks the proper infrastructural machinery to quantify solar radiation measurement (Adewuyi et al., 2019).

At the moment, Nigeria operates about thirty (30) measuring stations which are conducted by the Nigerian Meteorological Agency (NMA). These are airport- based and the data from these stations are used to calculate an estimate probability for solar radiation in the country (Udoakah and Umoh, 2014).

Nigeria is far behind its African counterparts, Kenya, Morocco, Senegal, South Africa, Rwanda, and Uganda. As a result, Nigerian is far away nearly competing with developing countries such as the United State of America, the United Kingdom, Germany, Denmark and Japan among others (Ozoegwu, Mgbemene, and Ozor, 2017). Evidence suggests that there is little local research and development activities related to solar energy in Nigeria. According to surveys conducted by the Energy Commission of Nigeria (ECN) in 1999, there are about 44 companies and research centres responsible for the importation and installation of photovoltaic systems in Nigeria. However, only one company (Exide Batteries Nigeria Limited) produces batteries that are used for photovoltaic solar systems in Nigeria, excepting facilities imported abroad for the same purposes (Odoakah and Umoh2014).

3.2.2 Solar Thermal

This is the process of where electrical energy is generated from solar radiation for use in an industrial setting and in residential or commercial sectors (Tian and Zhao, 2013). Solar thermal technology is widely used a crossed the world and proven to be effective and its applications include solar cooking, solar water heating, solar drying and solar irrigation in communities (Udoakah, 2014). In Nigeria, considerable research work has been done in this area. In fact, the National Centre for Energy Research and Development (NCERD) at Nsukka, Nigeria is internationally recognised for the research and development work it has carried out on solar absorption refrigeration and other upcoming projects that are expected

to be completed soon (Rita and Shu, 2016). Solar dryers, solar water heaters, solar cookers and solar chick brooders have been developed in various research laboratories around the country. However, many of these locally developed appliances, while functional, have not yet been developed to international standards (Oyedepo, 2014). Furthermore, most of them are only still at the research and development stages. None of the solar thermal applications are yet commercially viable in Nigeria, despite the fact that most of them are economically competitive with conventional applications (Emodi and Boo, 2015). In order to critically understand solar energy application and development in Nigeria, it's apparent to review literatures around other countries.

3.3 Status of solar energy installation across the United State of America, Europe Asia and Africa.

In recent years, the solar energy industry saw more robust expansion than ever before, up to 41% growth in 2013.This is an inspiring achievement considering carbon emissions have also recorded a peak in 2013, as it increased at a fast rate in 30 years, according to the World Meteorological Organisation. The report also showed that greenhouse gases were 142% higher than they were in 1750, before the Industrial Revolution (Andresen *et al*., 2014). Recently, the Environmental Protection Agency (EPA) and the United State Government laid out rules to cut carbon pollution produced by coal plants, the largest producer of carbon emissions, by 30% before 2030 (Omer, 2014). Research and development of renewable energy and adoption of alternative energy sources such as solar power are still at progressive stage, slowly heading in the right direction.

According to research by Green Tech Media (GTM), two-thirds of all solar energy technology worldwide were installed on or before January 2011. It's even more impressive because, the preceding four decades, only saw 50 gigawatts of solar energy installed

worldwide, (Zhang, 2015). According to Washington, DC-based nonprofit research organisation, The Solar Foundation, the US solar industry had 20% more jobs in 2013 than it did in 2012. The report also stated that the industry grew 53% in the last four years, adding nearly 50,000 jobs. Currently, there are more than 143,000 people employed by the solar industry (Mainzer *et al*., 2016).

According to Green Tech Media (GTM) research, the US is now installing one photovoltaic system every four minutes. If the market continues to grow at this pace, by 2016 there will be a system installed every 20 seconds (Mainzer *et al*., 2016). This is a huge growth since 2006, when one was installed every 80 minutes. Photovoltaic installations increased 41% over 2012 to reach 4,751 MW, according to GTM Research and the SEIA's Solar Market Insight Year in Review 2013. Solar was the second largest source of new energy electricity generation in the US (natural gas was first), and 410 megawatts of concentrating solar power came online, according to the report (Iniesta and Barroso, 2015).

The world's biggest carbon contributor, China, is making strides to harness clean energy. The country has set a goal of tripling solar installations to get to 70 gigawatts by 2017 (Andersen and Furbo, 2015).

China due to industrial activities, records more than 20 times the level of particulate matter in its air than ever before (Ozoegwu *et al*., 2017). Though, measures to lower the level of gas emission has since been a priority, including investment in green energy and sustainable practices. According to Heller (2015) most of the solar PVs recorded are rooftop and the solar panels can be much more efficient than they are usually perceived. The efficiency of solar panels has improved, but they have a long way to go before they are competitive with

coal and natural gas. Researchers at the University of California, Berkeley, said they have developed solar cells that are up to 25% efficient (Heller, 2015).

According to data from the National Renewable Energy Laboratory in the United State of America (USA), the primary research and development centre for renewable energy, only a quarter of commercial and residential rooftops are suitable for solar panels. It provides an opportunity for the communities (using services like Mosaic and Divvy) and community solar projects to drive solar energy initiative sharing system (Lara-Fanego *et al*., 2016). The full cost of installing solar power non-hardware costs, like development and financing, accounted for 57% of commercial systems and 64% of residential systems in 2012. While measures to cap the global warming and climate change is prioritised across the globe, the demand for solar energy continue to grow and the hardware prices continue to drop (Izquierdo *et al*., 2014).

According to a recent report by the International Renewable Energy Agency, an intergovernmental organisation that promotes the adoption of renewable energy, the cost of solar PV panels has decreased 80% between 2009 and 2013 and they will continue to drop (Mainzer *et al.*, 2016). Technological advancement and increase in efficiencies of solar panels contribute to rapid dropping of cost prices and increase in opportunities for low - income earners to acquire the initiative. However, most of the cost reduction is currently centred around the production process and installation of effective infrastructure which is the main hurdle for the industry to overcome (Akinbami, 2011) The next paragraph will discuss the status of solar energy initiatives across the United State of America, Europe and Africa, especially the Sub-Sahara region, with focus on opportunities, challenges and policies for scaling up the initiatives.

United State of America

The United State of America (USA) is the third largest solar PV market in the world, with estimated 2.6 gigawatts (GW) of solar PV by midst of 2019 (Burns and Kang, 2012). The current installed capacity is enough to power more than 14 million American homes. U.S is experiencing a rapid growth in demand for solar PVs with an average growth rate of 71% per annum (Pesch, 2018). U.S possesses a truly engender sustainable long-term market, making it the third global demand dominant behind Germany and Spain. The U.S.is potentially in the forefront in solar energy opportunities for development, financiers, installers and other solar PV services providers as many global industry players emulate the U.S. market strategy for PV promotion (Dicer, 2011). The solar industry in the U.S is aimed to meet 10% of U.S peak electricity generation capacity by 2030 and 25% by 2040. Also, the solar energy industry in the U.S is expected to employ more than 150,000 people in the industry within the next 20-25 years and to grow its financial investment to $15 billion by 2020 (Gorman, Mills and Wiser, 2019).

China

The People Republic of China has the largest electricity supply system in the world, after taken over the United State of America in 2015 (Liu *et al*., 2010). 65% of the Chinese primary energy is derived from coal, which result in a significant contribution to co_2 emission and global warming (Wang, 2016). The impact of the global warming to the climate change creates a serious threat to human's health and the environment. China, one of the fastest growing economy in the world with a population of more than 1.4 billion people, hugely needs energy to thrive the competitive economically around the world. Considering the economic growth of about 10% per year, China energy usages and demand

have become increasingly important and as such renewable energy plays a vital role in the country's socio-economic development. China is well known for its vast land with abundant solar energy resources of annual solar radiant energy up to 1.7 x 10^{12} Tce. In 2007, China announced its intention and target to install 300 MW of PV by 2012 and 1.8 GW by 2020 (Zhou *et al*., 2018). However, China has embarked on several solar energy projects resulting in real market potential to ramp well beyond 2 GW in 2018. According to the present plan, total PV power installations will reach 1.8 GWp by 2020 and 1000 GWp by 2050 (Wang, 2010). According to forecasts made by the Chinese Electric Power Research Institute, renewable energy installations will account for 30% of total electric power capacity in China by 2050, of which PV installations will account for 5%.

Japan

Japan has been a country that relies on more than 80% of its energy from imported petroleum resources, as a result, it became one of the countries with high CO_2 emission (Ustun *et al*., 2019). In recent years, Japan has diversified and made a significant progress in the energy market with huge investment in the production and assembling roof type solar PV technologies (Li, Xu and Shiroyama, 2019). One of the strategies adopted in Japan to promote and encourage the spread of awareness about solar PV is the introduction of the subsidy system. Japan plays a vital role not only in Asia but across the globe as a market player in the global and domestic supply of PV industries and was termed the second largest in 2004 (Strupeit and Palm, 2016). As part of expansion strategy, Japan has set up a long-term roadmap called PV 2030 through the discussion by the NEDOs PV 2030 roadmap study committee. It is expected that the domestic PV installation will reach 100 GW by 2030.

Germany

Germany, despite being one of the countries with least sunshine hours in the world, is one of the largest solar energy producers not only in Europe but around the globe (Kasbergen, 2012). Germany has an installed capacity of Solar exceeding 43 GW in 2017 and has a projected expansion of 98 GW by 2030. The country is ranked 4th in the world according to the International Energy Agency (IAE) (Mundo-Hernández, 2014). Germany had over 1.64 million solar arrays installed across the country in 2018, making it account for almost 10% of the total global solar installed capacity. In contrast to a system focused on big and centralised power producers, thousands of solar panel operators are becoming an increasingly important part of the German energy system (Vladimirovna, 2018). The number of solar panel producers and service companies skyrocketed quickly, as investors rushed to reap the benefits of this large-scale technology support. However, after its quick ascent to world leadership with less than a decade, the country's solar energy industries suffered an even more rapid decline by competitors, especially from China (Marculescu, 2014). China offered solar panels at much cheaper rate than German manufacturers as a result, the guaranteed remuneration dropped by 80% around 2015.

Spain

Before 2005, 80% of the energy consumption in Spain has been from imported sources. The Spanish government diversified into energy options and approved the Renewable Energy Plan 2005-2010, which aimed to supply 12% of Spain primary energy from renewable and up to 30% of the electricity demand from renewable sources (Pe asco, 2019). Spain has an abundant sunshine, making it a big opportunity for solar energy resources with 1200-1800 kWh m^{-2} $year^{-1}$. Spain has the highest global solar irradiation in Europe, estimated between

1.48 and 3.56 kW/m^2 days (Ridao, 2007). More than 250 companies are actively engaged in the production, trading, developing and promoting solar PVs. The initiative is estimated to generate more than £1.5 billion turnover and accounts for more than 3900 jobs in the country (Dollinger and Dietrich, 2013). Spain is now the PV market leader with not less than 6.9 GW of new grid-tied installation. As a result, Spain has been considered as number 2 in Europe behind Germany with potentials to overtake Germany due to the abundant solar energy potentials (Ordonez, 2010). The biggest solar parks: being the 60 MW Olmedilla photovoltaic parks is in Spain and several new large-scale solar energy projects are in the pipeline for scaling up Commercial Concentrating Solar Power (CSP). A study published by Greenpeace International, the European Solar Thermal Electricity Association (ESTELA) and the International Energy Agency's SolarPACES in May 2009 estimated that CSP could meet up to 7% of the world's power needs by 2030. The Spanish government has approved a new Plan to develop renewable energies, buys shares of CO2 emissions to seller countries, buys foreign reforest and establishes saving and energy efficiency strategies.

Table 3.1 Top Ten Countries for Solar Installations and Total Installed Capacity in 2019.

	FOR ANNUAL INSTALLED CAPACITY				FOR CUMULATIVE CAPACITY	
1	China	30,1 GW	1	China	204,7 GW
(2)	*European Union*	*16,0 GW*	(2)	*European Union*	*131,7 GW*
2	United States	13,3 GW	2	United States	75,9 GW
3	India	9,9 GW	3	Japan	63 GW
4	Japan	7,0 GW	4	Germany (EU)	49,2 GW
5	Vietnam	4,8 GW	5	India	42,8 GW
6	Spain (EU)	4,4 GW	6	Italy (EU)	20,8 GW
7	Germany (EU)	3,9 GW	7	Australia	14,6 GW
8	Australia	3,7 GW	8	UK (EU in 2019)	13,3 GW
9	Ukraine	3,5 GW	9	Korea	11,2 GW
10	Korea	3,1 GW	10	France (EU)	9,9 GW

Source: Enkhardt, (2020)

In table 3.1, China, the European Union and the United State of America are the top leaders in the global annual solar energy installed capacity. China has 30.1 GW and 204.7 GW of annual and cumulative installed capacity, respectively. While China is leading in the solar energy installation, African region is slow in the process of harnessing electricity from solar despite the huge potential in the continent. Therefore, there is a need to further investigate the status of solar energy development in the continent.

Solar Energy Potential in Selected African Countries

The entire African Continent (see Figure 3.1) the Sahara in the North, Southern Africa, West Africa and East Africa are full of potential sunshine, with the opportunity to harness the resources to renewable energy sources (Amankwah-Amoah, et al. 2018). The study is based around Nigeria, Ghana, South Africa, Kenya and Chad Republic to get the richness of the Sub-Sahara Africa.

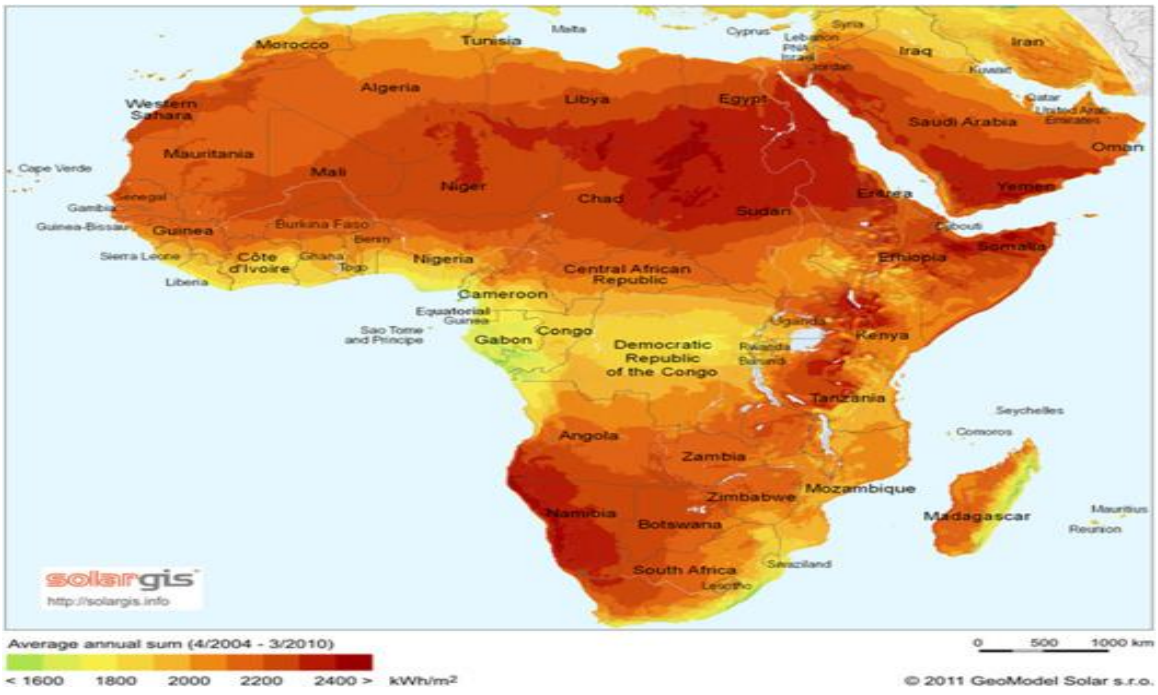

Figure 3.1 Average Annual Sun Irradiation in Africa

Source: Abubakar, et al. (2016).

There are over 1000 major solar energy projects flagged across the African continent in recent years, most of which are either completed or are in progress to completion (Abubakar *et al*., 2016). Most of the projects are financed privately by local and international investors, while others are under the public/private partnership within Africa and other international partners. Twenty-one projects were identified, and the details are shown in table 1. Udi solar plant is the highest in terms of capacity of 1,200 (MW), while Accra solar PV is the project with the lowest capacity of 20 (MW). Further details of each country are explained below:

South Africa

South Africa is a Nigerian counterpart with the second largest economy in Africa, the Northern Cape is considered as the region with potential sun irradiation for solar energy development. South Africa also has a strategy for developing alternative energy sources known as Solar Energy Technology Roadmap (SETRM) (Fluri, 2009). It is a joint initiative

with the Department of Science and Technology (DST), supported by the International Energy Agency (IEA) and the Deutssche Gaselischaft fur' Internationale Zusammenarbeit (GIZ) for the South African-Garman Energy Programme (SAGEN) (Lotz and Brent, 2014). The completed designed roadmap for the solar energy technology consists of three sector components: Concentrated Solar Power System (CSP), Solar PV and Solar Thermal initiatives, venturing into research and development for hybrid and solar fuels (Fluri, 2009). South Africa strategy for renewable energy and electricity roadmap, is to generate 40GW of solar PV and 30 GW of CSP on or before the year 2050 (da Silva *et al*., 2018). The next paragraph discusses solar energy status and progress in Kenya, Eastern part of Africa.

Kenya

Kenya is also one of the fastest growing economy in the Central and Eastern Africa with a thirst for renewable energy development. Kenya is in the forefront, investing in renewable energy to meet the energy demand of the growing population (Kiplagat *et al*., 2011). The energy growth, progress is 18% annually superseding that of Nigeria and Ghana of 15% per annum. Similar to Nigeria, the rural communities in Kenya have limited access to electricity; as a result, socio-economic development is challenged (Roche and Blanchard, 2018). Currently, standalone solar system is deployed to 220 secondary schools with capacity of 574.22kW at the cost of 6.16 million Euros (Hansen *et al*., 2019). More tenders have been offered for more than 117 institutions to be electrified with solar at an estimated cost of 2.5 million Euros (Pueyo and DeMartino, 2018. Other projects on the stream are the proposed 380 selected institutions to be electrified with the stand alone solar system awarded to Spain electricity for the cost of 10 million Euros (Hansen *et al*., 2019). The next paragraph discusses the solar energy status in Ghana, Western Africa.

Ghana

Ghana is one of the smallest countries in the West African region with a population of approximately 28 million people. Ghana solar indicates a radiation level of 4-6kWh/m2 providing great potentials for solar energy exploitation (Asumadu-Sarkodie *et al*., 2016). It is expected that Ghana electricity access will increase by 6% - 10% once the Nzema solar project is completed with 155 MW PV installation (Amankwah, 2015). More projects are underway and expected to bridge the 40% gap between the urban and rural electrification access (Atsu *et al*., 2016). Ghana is readily pushing towards achieving the Sustainable Development Gaols (SDGs) with indicators scaling towards solar PV and other renewable energy initiatives (Asumadu-Sarkodie *et al*. 2016). There is a plan to establish more than 55 solar based mini grids with an average capacity of 10-15 MW. More than 200,000 solar home lighting in selected urban cities, such as Accra, Kumasi, Sekondi- Takoradi, Sunyani and Tamale (Atsu *et al*., 2016). The next paragraph discusses the solar energy status and projects in Central African Region, Chad Republic.

Chad

Republic of Chad lies in the Central African region with a population of less than 15 million people (WORLDBANK, 2018). The electricity source is mainly from fossil fuel and wood charcoal, impacting on the emission release of 0.53 CO2 of greenhouse gasses (Babikir *et al*., 2020). One important renewable energy policy formulated by the country's government is the system of renewable energy diversification into solar and other renewable. The policy provided the necessary framework for developing renewable energy schemes (Soulouknga *et al*., 2017). There has been a great success as far as the attainment of renewable energy goals in recent years (Laurent and Whitehouse, 2017). For instance, the country benefited

from a sustainable energy fund for Africa, a loan aimed at the development of a 40 MW solar plant in the country (Tidjani and Chandra, 2012). The investment is carried out by Starsol Solar PV and the plant is located near the capital city of N'Djamena (Tidjani and Chandra, 2012. There is a huge potential for solar energy, especially the northern part of the country.

Table 3.2 Major Solar Energy Projects in Africa

Name of Project	Capacity	Details	Location/Country
Noor Solar Complex	510 MW	Biggest concentrated solar power plant project in the world	Agadir District of Morocco.
Solar Capital De Aar Project	175 MW	Developed by solar capital with 2 phases (De Aar1 -De Aar 3)	Northern Cape, South Africa.
Benban Solar Project	165.5 MW	Developed and financed by ACWA power ($190)	Aswan Province in Benban, Egypt.
KaXu Solar One	100 MW	Utility Eskom PPP, under 20 year power purchase agreement.	Northern Cape, South Africa.
Xina Solar One	100 MW	Concentrated solar power plant that offer 5.5 hours solar thermal	Pofadder, South Africa.
Ilanga-1 CSP Plant	100 MW	Developed and commission by SENER/Emvelo in 2018.	Karoshoek, Northern Cape, South Africa.
Kathu Solar Park	100 MW	Owned by Engie, SIOC Community Development Trust	Kathu in Northern Cape, South Africa.
Jasper Solar Power Project	96 MW	Developed by SolarReserve and Kensani and Intekon Energy.	Postmasburg, North Cape, South Africa.
Mulilo-Sonnedix-Prieska PV Project	86 MW	By Mulillo RP Developent and Ixowave Women power (Pty).	Northern Cape, South Africa.
Kalkbult Solar Plant	75 MW	Grid connection of 312,000 solar panels, generate up 135GWh.	Petrusville, North Cape, South Africa.

Source: Amankwah-Amoah, (2015); Abdullahi et al., (2017a).

Although, African continent is highly endowed with potential solar energy opportunities, the development and application process for implementation is slow and need a proactive strategy to drive the industry to implementation stages. Figure 3.1 identified policies adopted by few countries across the African continent to promote, develop and implement solar energy initiatives in the region.

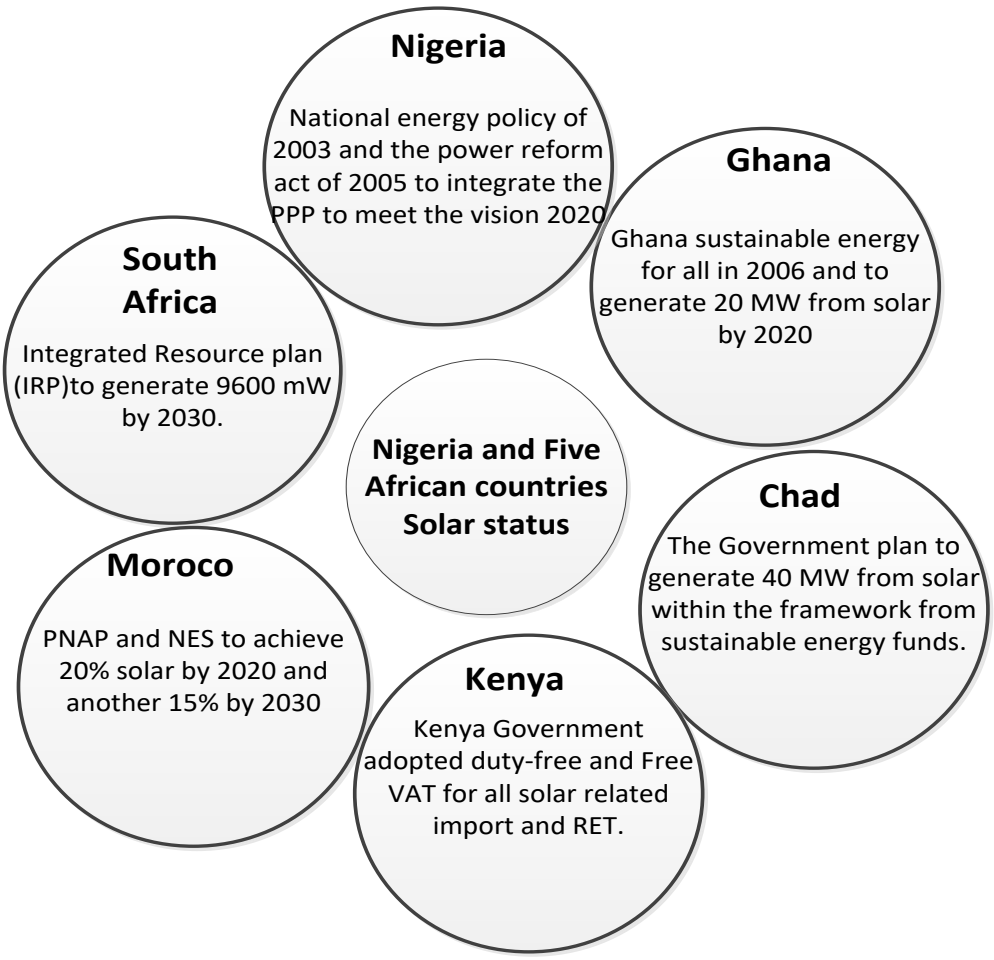

Figure 3.2 Selected African Countries and Solar Energy Policies Adopted

Figure 3.2 above, shows in brief the policy strategies employed by each country with aims for achieving a sustainable target of solar energy initiatives. Most of the policies and strategies are interrelated; Nigeria for instance, is on closed target with Morocco, where Nigeria proposed to achieve solar energy generation of 15% by 2020, 20% by 2030 and 50% by 2050. Although, South Africa and Morocco are leading in the solar energy generation, the Nigerian government and the private sector are making a significant progress to awareness creation and sensitisation on the benefits associated with solar energy initiatives.

Nigeria is among a growing number of countries in Africa and have employed state capital to start state-owned solar firms to allow local manufacturing facilities to develop. Ubbink East Africa is a small-scale module manufacturing firm that has emerged in the PV cell and module business across the continent that facilitates collaboration between local and foreign companies for domestic manufacturing. The growing government support for these small-scale module manufacturing firms, provides only a limited window of opportunity for them to gain a foothold in the market given the growing competition from Chinese, South Korean, and Taiwanese firms in the industry (Ouedraogo, 2019).

3.4 Status of Solar Energy in Nigeria

The entire African continent is blessed with tremendous sunshine radiation, especially the eastern Sub-Sahara North-eastern Africa almost throughout the year. The regions recorded more than 4,300 hours of bright sunshine equivalent to 97% of the possible annual value of solar irradiation (Duke *et al*., 2015). The only areas exceptionally recorded with low sunshine irradiation are the Guinea forest of West Africa around the Congo Basin (Nwokolo and Ogbulezie, 2018). The dispersal of solar energy resources across Africa is uniform with more than 85% of the continent's landscape receiving a global solar horizontal irradiation of over 2,000 kWh/ (m^2 year) (Akinyele, 2015). Even though, solar thermal has been enjoyed by rural dwellers for agricultural purposes, including drying of food crops, water irrigation pumping, and farms animal lighting. Other purposes are lighting for homes, vaccines storages in health centres and schools in rural communities (Aliyu *et al*., 2015). Solar energy technologies such as PVs are widely used in Nigerian urban cities such as Abuja and Lagos and Port-Harcourt for home lighting, cooling and domestic uses of less than 1.5 MW installed capacity. The most recent progress made is the solar street lighting that is deployed across many urban cities in the country. Notably, the Sokoto Energy

Research Centre (SERC) has built a 1000-litre capacity solar heating system at the Usman Danfodio University Teaching Hospital Sokoto (Abdullahi *et al*., 2017a). Other stand-alone mini grids are installed and scattered across the country by the government and its agencies.

Literature revealed that Nigeria has adequate solar radiation to be utilised for electricity generation, especially the northern part of the country where solar radiation is approximately 7 kWh/m^2, while the solar radiation in the southern part stands 4kW h/m^2 respectively (Ozoegwu *et al*., 2017). The current installed capacity of solar energy initiative, approximately 15 MW and expected to reach 30 MW by the first quarter of 2019. The installed solar PVs are virtually standalone solar system for electrification as off-grids (Ozoegwu, 2018). In 2003, the federal government of Nigeria through the federal legislation approved the Nigerian solar energy policies, in which for the first time, Nigeria prioritising the energy mix with indicators for long-term policies as per table 1 (Aliyu et al., 2015). The policy documents projected that Nigeria could achieve 1 GW of solar electrification within 10 years, unfortunately, the target is missed due inability to track, monitor and evaluate the progress of solar energy projects in the country. The Electric Power Sector Reform Act (EPSRA) 2005 initiative attracted investors, nationally and internationally to participate in the Public Private Partnership (PPP) process for energy mix. Germany has already committed up to 2 million Euro to help Nigeria boost the power generation and to meet the high demand of power energy (Ogunmodimu and Okoroigwe, 2018).

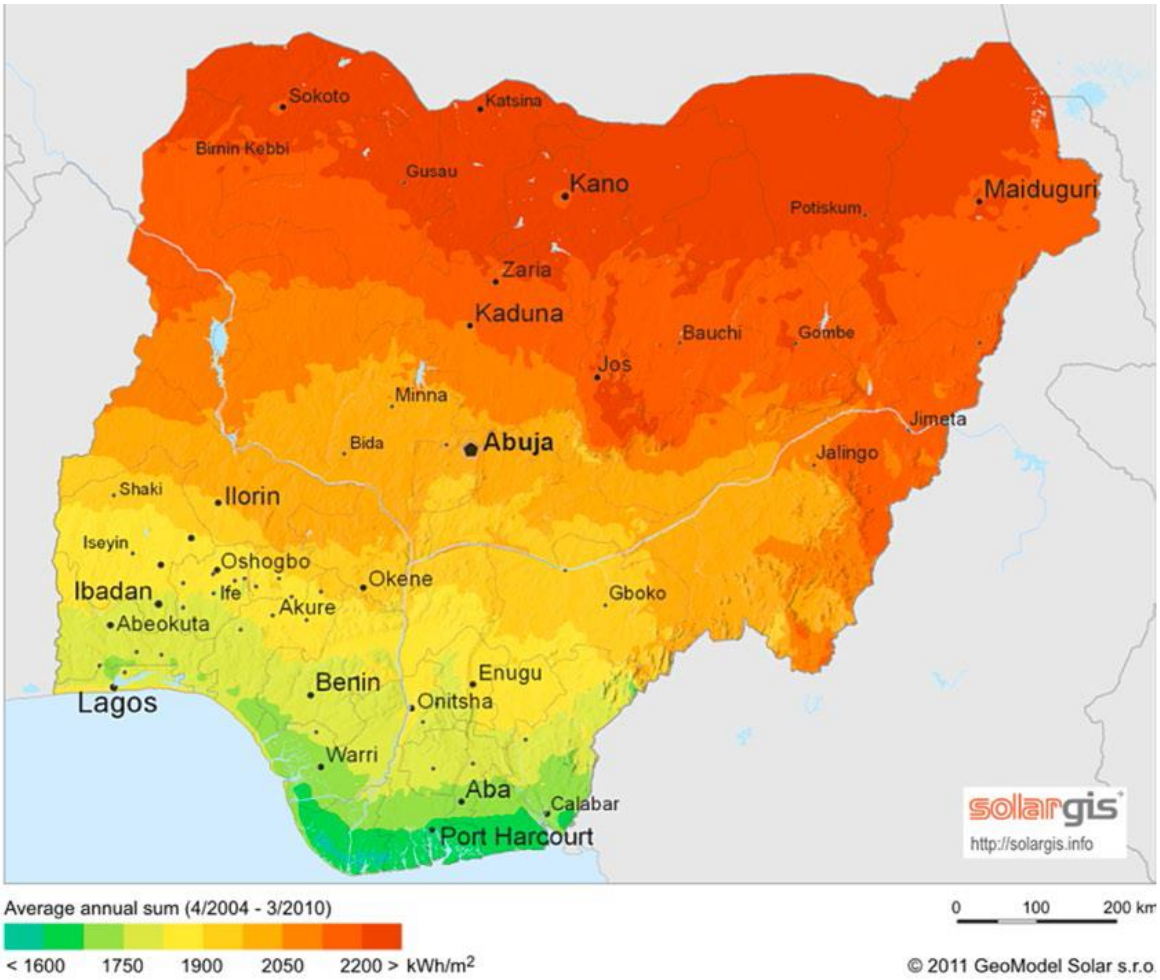

Figure 3.3 Solar Irradiation levels in Nigeria

Source: NESP, 2015

3.5 Existing Solar Energy Projects in Nigeria

There are more than 58 Solar-based projects in Nigeria, including rural electrification projects, with a total capacity of 115 MW of Photovoltaic combining mini-grids and stand-alone installed (Shaaban and Petinrin, 2014). The Solar-based projects are installed for residential and commercial purpose respectively. Even though, the Ministry of Power launch a project in 2014, known as ‘‘Operation Light Up Rural Nigeria’’ most of the Solar projects is targeted for rural communities which are estimated only 10% of the population have access to electricity.

3.5.1 Potential Solar Radiation in Nigeria

Table 3.3 Max/min. yearly global solar radiation in Nigeria (kWh/m2/day)

Stations	Location Longitude	Location Latitude	Altitude M	Maximum A	Minimum B	Monthly Average
Abeokuta	7.25	3.42	150	4.819	3.474	4.258
Abuja	9.27	7.03	305	5.899	4.359	5.337
Akure	7.25	5.08	295	5.172	3.811	4.485
Azare	11.8	10.3	380	6.028	5.022	5.757
Bauchi	10.37	9.8	666.5	6.134	4.886	5.714
Benin city	6.32	5.677	77.52	4.615	3.616	4.202
Calabar	4.97	8.35	6.314	4.545	3.324	3.925
Enugu	6.47	7.55	141.5	5.085	3.974	4.539
Ibadan	7.43	3.9	227.23	5.185	3.622	4.616
Ilorin	4.48	4.58	307.3	5.544	4.096	4.979
Jos	9.87	4.97	1285.58	6.536	4.539	5.653
Kaduna	10.6	7.45	645.38	6.107	4.446	5.672
Kano	12.05	8.53	472.14	6.391	5.563	6.003
Katsina	13.02	7.68	517.2	5.855	3.656	4.766
Lagos	6.58	3.33	39.35	5.013	3.771	4.256
Lokoja	7.78	6.74	151.4	5.639	4.68	5.035
Maiduguri	11.85	13.08	383.8	6.754	5.426	6.176
Makurdi	7.73	8.53	112.85	5.656	4.41	5.077
Minna	9.62	6.53	258.64	5.897	4.41	5.427
New Bussa	9.7	4.48	152	5.533	4.15	4.952
Nguru	12.9	10.47	342	8.004 *	6.326	6.66
Ubudu	6.63	9.08	305	5.151	3.375	4.224
Oweri	5.48	7.03	120	4.649	3.684	4.146
Port Harcourt	4.85	7.02	19.55	4.576	3.543	4.023
Serti	7.5	11.3	610	4.727	3.972	4.488
Sokoto	13.02	5.25	350.75	6.29	5.221	5.92
Wari	5.52	5.73	6.1	4.237 *	3.261	3.748
Yola	9.23	12.47	186.05	6.371	4.974	5.774

Source: Emodi and Boo, 2015

It is evident that the northern part of Nigeria can generate substantial solar energy as seen in table 3.3; with annual radiation rising up to 6.966 maximum in Nguru Yobe state in North-East and 3.78 minimum in the Wari Delta state, South South of Nigeria. The next table shows major solar projects both public and private with licence to generate operate and commercialise solar energy in Nigeria.

3.5.2 Solar Projects in Nigeria

Table 3.4 Major Solar projects in Nigeria

S/N	Name of Solar projects	(MW)	Type	Location	Proponent
1	Anjeed Kafanchan Solar Ltd	50	Solar	Kaduna	Anjeed Innoval Ltd
2	PV Grid – tied generator system	50	Solar	Osun	Book Solar Invest.
3	Ever Power Solar power plant	50	Solar	Kaduna	Quaint Global Energy
4	Solar Farm Projects	200	Solar	Borno	Borno State Govt.
5	Solar Farm at Kado	59	Solar	Kaduna	Synergent powershire
6	Solar Indep. Power Project	100	Solar	Bauchi	Nigerian Solar Capital
7	Solar PV Power Projects	50	Solar	Sokoto	Geo Envi. services
8	Solar Farm Projects	30	Solar	Katsina	Katsina State Govt.
9	Japanese Grand Solar Power	0.9	Solar	FCT	Fed.Min. of Power
10	On-Grid Solar Power	200	Solar	FCT	99 Effect Energy Ltd
11	PV-Solar Farm Kankia	20	Solar	Katsina	Katsina State Govt.
12	Solar Project Danmarke	75	Solar	Zamfara	SPGS Power Ltd
13	Solar Power Plant Panyam	50	Solar	Plateau	CT Cosmos Ltd
14	Solar Farm Riko, Jibiya	10	Solar	Katsina	Sinosum Investment
15	Solar Gen. Plant Damaturu	1000	Solar	Yobe	GOPA Int.Energy Cslt
16	PV Power Plant FCT Area	100	Solar	FCT	LR-Aaron Power Ltd
17	Shiroro Solar Power Projects	300	Solar	Niger	N/South Power Co.
18	Solar Power Plant Irewole	50	Solar	Osun	Remix Energy Ltd
19	Solar Power Plant, Bakura	150	Solar	Zamfara	PV Bakura
20	Solar Power Plan Owo	25	Solar	Ondo	Secusafe Limited
21	Solar Farm Gusau	50	Solar	Zamfara	Sinosun Investment
22	Solar Panelled Power Projects	NA	Solar	Nassarawa	Evansol Solar Ltd
23	Solar Farm Kiru	40	Solar	Kano	Bravos Energy Res.
24	Solar Project Kankia	125	Solar	Katsina	Nova Solar 5 Farms
25	Solar Energy Projects Udi	1200	Solar	Enugu	Motir Seapire Energy
26	Solar Plant Dutse	NA	Solar	Jigawa	Nova Scotia Power
27	Solar Power Plant, Ilorin South	150	Solar	Kwara	Oroceram Limited
28	Solar Power Plant, Paiko LGA	150	Solar	Niger	Oroceram Limited
29	Solar Power Plant, Dutse	75	Solar	Jigawa	PAS Dutse Ltd
30	Solar Power Plant Hadejia	75	Solar	Jigawa	PAS Dutse Ltd
31	Solar Energy Projects Gwa AC	NA	Solar	FCT	Super Solar Ltd
32	Solar Power Projects Gwa AC	100	Solar	FCT	Enerlog Limited
33	Solar Projects, Yabo	100	Solar	Sokoto	KVK Power
34	Solar Power Plant, Kankia	80	Solar	Katsina	Pan African Solar Ltd
35	Solar Power Plant, Bakura	300	Solar	Zamfara	Bakura Energy Ltd
36	Solar Plant Kokona	50	Solar	Nasarawa	Afringia Power Ltd
37	Solar Power Plant, Numan	35	Solar	Adamawa	Hill Crest Env. Ltd
38	Renewable Energy Owo	10	Solar	Ondo	Gottpower Limited

Source: ECN, 2016; FME, 2016

Table 3.4 is projects contracted and approved by the Nigerian government. The list of the projects is not exhausted because the projects are continuing where contract proposal are assessed, evaluated and reviewed for viability and competency for the award. These projects

are scattered throughout the region where progress is monitored with closed supervision from the stakeholders.

Table 3.5 Other Solar projects in Nigeria.

S/N	Projects	Projects	Location	State
1	Solar-based	3	Bayelsa State	Bayelsa
2	Solar-based	11	Benue State	Benue
3	Solar-based	9	Delta State	Delta
4	Solar-based	1	FCT	Abuja
5	Solar Farm for bio-fuel	1	FCT	Abuja
6	1.820 kWp Solar-Based	1	FCT	FCT
7	Solar Pilot Projects	1	Mallam Inna	Gombe
8	Solar-based	5	Jigawa State	Jigawa
9	Solar-based	8	Kaduna	Kaduna
10	Solar-based	10	Katsina	Katsina
11	Solar-based street light	1	Lagos State	Lagos
12	Solar-Based	4	Taraba	Taraba
13	Solar-power borehole (1.565) kWp	1	Jigawa State	Jigawa
14	Solar-based (2.85) kWp	1	Abia State	Abia
15	Solar-based (1.75) kWp	1	Akwa-Ibom State	Akwa-Ibom
16	Centralised Solar plant (7.5) kWp	1	Oyo State	Oyo State

Source: NERC, 2016

The other solar projects in table 3.5, are projects under the review for license and other due procedures as stipulated by the energy commission of Nigeria (ECN) and Nigerian Electricity Regulatory Commission (NERC) as part of the Electric Power Reform Act strategy for energy mix.

In spite of these data related to solar energy discussed in Nigeria there is no empirical studies on the drivers, barriers and benefits of the solar energy implementation in Nigeria. Henceforth a thorough literature review had to be carried out.

3.6 Drivers for deployment of Solar Energy

Each country's location might have potential for different factors that drives the deployment and implementation of solar energy initiatives. For developing countries solar energy can bring major benefits for socio-economic development, especially in the rural communities where access to electricity has become the biggest challenge. Diversifying from oil and gas

to the solar energy resource and other renewable energy initiatives can reduce the over dependency on oil and gas supply. In the south, and other developed countries, leaders have taken the advantages to driving the renewable energy from international climate change agreements like the Kyoto Protocol, SDGs and from socio-economic interest. In other words, fast economic growth countries like China, India, and Brazil are mandated to meet their energy demand while the poorer nations must meet the international poverty reduction goals which implies the reduction of energy poverty especially in the rural areas in Africa particularly Nigeria. The literature reviews have identified nine key drivers for solar energy initiative's implementation, which are discussed in detail below:

Sustainability demands (CO_2 footprint and Climate change)

Climate change is the main driver for solar energy and other renewable and the main trigger for the called for MDGs and SDGs over the Years (Audu and Okeke, 2019). Nigeria is lying on the coastline of about 800 km, with sea level risen to 0.2 m and approximately 3400km sq. Several kilometres of land around the world are lost to climate change impact whilst the damage to aquatic habitats cannot be over emphasised (Matlock, 2009). The raising of the sea level and the desertification is resulting from the burning issues of the rapid greenhouse emission. The application and development of solar PV could reduce the impact to a minimal level while tapping the free and clean energy and making our environment friendly, more sustainable and greener (Cervigni *et al*., 2015).

Increased energy demand

As the population grows fast around the world, the energy demand is also on the increase as such the demand and supply gap most be bridged by sustainable energy option. The population growth has a direct correlation with energy demand due to infrastructures,

facilities and small -scale businesses (Consumer Group, 2019). In Nigeria for instance, population growth is expected to reach 270 million by 2030 at an average annual rate growth of 4.0% between 2000 and 2030. Hence the demand for energy will rise to meet the socio-economic activities of the people in both urban and rural communities (Oseni, 2012). Future economic growth is linked to an increasing digitalisation and electrification, which is offset by energy efficiency development. As a result, developing economies, increasing income, expanding industrial opportunities and growing the service sector which pushes the demands firmly high.

Energy Security and access

It has been a global challenge to which country can deliver a secure, affordable, and sustainable solar energy which is known as energy triangle. The need to become more energy-efficient, more diverse to energy options, and less carbon--intensive on climate change is critical for major emerging economies, making it crucial to progress with government responses to these pressures through energy reform (India in 90, 2016). An increase in regional prosperity has brought several challenges, including the high demand of energy to sustain potential opportunities especially in urban cities around the world. In Africa, access to electricity is challenged due to insecurities such as transmission lines destructions and theft (Emodi, 2015).

To Neutralise the energy conflict

In recent years, the energy industry has experienced an increase in demand due to increase in needs by population. Hence, there an overwhelming conflict between the oil and gas industry that supplies the raw material to conventional electricity and the green energy options (Oscar *et al*., 2012). The need for resolution to neutralise the conflicts has called for

the power sectors to diversify into renewable energy like solar PVs. As the energy industry needing a new pipeline to conform with the SDGs goal seven, lifting the regulatory burden with a new approach from government and all stakeholders (Morgan, G. 2019). Integration of all sources of energy to increase energy access and mitigate energy poverty can neutralise the energy conflict, especially in Nigeria, where connect to grids and other energy options are limited.

Job Creation and Opportunities

The promotion and deployment of solar energy initiatives will contribute enormously to poverty reduction by engaging young people in local communities to participate and benefit from the opportunity in skills development, technology transfer and investment opportunities (Chakraborty *et al*., 2020). Many alternative energy pilot projects in developing countries give positive evidence of impact on socio-economic development, especially the rural communities with abundant isolated natural resources that remains unexplored Ohunakin *et al*., 2014). The increase in the investment in the solar battery manufacturing, installations, maintenance and repair skills, and the manufacture of various solar devices leads to the creation of massive job opportunities (Edomah *et al*., 2016).

Local value-added potential

Developing countries will yield local added value for solar energy penetration, considering that all nations have strived courage to meet the SDG goal seven targets (First Solar, 2013). It is evident that quite number of the population of each country lives in rural communities, especially around the African and Asian continents. Deployment of solar energy initiatives in these regions could create local value to the people and increase the country's GDP output (Sooriyaarachchi *et al*., 2015). There is a potential for the solar applications technology to

be developed locally by the rural dwellers to support an energy mix in various forms such as cooking, water pumping, skill acquisition and job creation (Emodi and Boo, 2015).

Growth in Education and Technology

Growth in technology and widespread of technical knowledge of solar technology could be a reason driving the need for solar energy deployment around the world. In recent years, there has been an increase of new courses on solar and renewables across universities and colleges around the world (Ulsrud *et al*., 2011). Besides, the institutions, they are several training and technical centres for solar panel manufacturing and assembling across the globe and this thirst are driving the need for solar energy implementation (Kanters and Horvat, 2012). Education and technology is taking a new dimension to green energy in the design of buildings, transport systems and infrastructure as such the need for solar energy initiative cannot be over emphasised.

Stakeholders Involvement

Solar and other renewable energy projects cannot succeed without the intervention of local stakeholders. When local entrepreneurs, explicitly integrates their investment towards solar energy technology, the success of the technology is achievable (Sisodia *et al*., 2020). Schelly *et al*., (2019) argued that local investors, entrepreneurs, and end users are encouraged to fully participate in the promotion, generation, production and implementation of solar energy to encourage socio-economic activities. In many African countries for instance, there is a shortfall in electricity access and therefore, solar energy options are best opportunities that stakeholders need to integrate in energy development plan (Sisodia *et al*., 2020).

Financing opportunities and Market potential

One of the barriers to solar and renewable implementation in developing countries are the inability to penetrate a market because the technology is yet to be known and accepted in many countries (Elmustapha and Hoppe, 2020). However, incentive mechanism such as subsidies towards the initial financial cost of solar could play a vital role in promoting the technology (Hubert, 2013). Solar energy deployment such as standalone electricity has the capacity to support small scale business and burst social amenities like water heating, water pumping and lighting (Kar, Sharma and Roy, 2016). It is evident that many communities in Africa and Asia have been supported by the world bank and other international aid projects for solar energy deployment and the projects create local financial opportunities to the communities (Sovacool, 2018).

The literature has identified nine factors that drive the need for solar energy implementation across the world. However, there is a need to further investigate drivers for solar energy implementation in Nigeria, which will address research objective two and is presented in chapter six. The next section discusses barriers that challenged the solar energy implementation.

3.7 Key Barriers to Solar Initiatives

Despite the many benefits that can be accrued from the use of solar energy potential and uses, is still very low. The major impediments to the technology adoption are series of barriers which makes it hard to implement (see table 3.6).

Table 3.6 Barriers to Solar energy implementation

category	Barriers	Remarks	Sources
Technical Barriers	Lack of skilled personnel, lack of code of standard, lack of maintenance and operation, lack of training facilities and entrepreneur's development mechanism, lack of Reliability.	The barriers lead to poor plans, poor standard, and constraints of the competitive market, inadequate knowledge to know-how about the technology and risk acceptance. All these barriers resulted in technology locked -up.	Sambo & Bala, 2012; Painly, 2001; Luthra, *et al*. 2015.
Social. Cultural Behaviour	Lack of consumer awareness about the product, lack of understanding of benefit of solar PV and public resistance to chance for new technology.	The barrier affects the market projection negatively, cultural and religious faith controversies towards economic development and sustainability.	Pasqualetti, 2011; Pollmann, et al. 2014; Akinwale, *et al*. 2014.
Economic/ Financial Barriers	Lack of access to capital, credit to consumers and financial instrument. Lack of support to R & D, high interest rate, import duties subsidies to support local manufacturing.	At the early stage, solar projects need incentives to encourage entrepreneurs. The barriers make it difficult to adopt and sustain due to financial constraints.	Shaaban & Petinrin, 2014; Emodi &Boo, 2015; Kar & Sharma, 2015.
Institutional / Legal barriers	Institutional barriers, legal framework, regulatory issues, non-integration of energy mix, non-participation of private sector, poor R & D culture and stakeholder's non-interference.	High risk of uncertainty in support of solar energy, lobbies against RET, poor communication mechanism to reach the institutional policy makers for improvement and negative perception about the technology.	Aliyu, *et al*. 2015; Charles, 2014.
Political/ Policies Issues	Lack of long-term policies, lack of political will to diversify into clean energy, constantly changing of government and re-shuffling of institutions.	These barriers serve as a deterrent to future planning for solar and other renewable energy adoption and sustainability. There is the fear of uncertainty in government.	Sambo & Bala, 2012; Ohunakin, et al. 2014; Painuly, 2001.
Market Distortions Issues	Trade barrier for new product, energy sector controlled, lack of access to diversified technology, lack of facilities and backup technology, non-market-oriented research for solar energy technology and application.	The barriers cause hindrance to market penetration and hence new technology failed at some point.	Ohunakin, et al. 2014; Fagbenle, *et al*. 2011.

Through literature review six barriers for solar energy implementation across the world have been identified (See Table 3.6). However, there is a need to further investigate barriers for solar energy implementation in Nigeria through empirical studies which will address research objective two and is discussed in chapter seven. As Nigeria is potentially located in the Sunbelt on the equator with an opportunity to power the entire country with solar by

just using 1% of its land. Anecdotal evidence suggests that the threat of the solar energy initiatives includes massive production and importation of substandard solar panels and storage facilities in the country which could lead to poor acceptance of the product by the end users.

3.8 Key Benefits for Implementing Solar Energy Strategy

Solar energy implementation has plenty of benefits and these are discussed below in details:

Environmental benefits: Solar energy initiatives have zero emission and therefore, the implementation can help in saving the environment compared to the traditional means of electrification from fossil fuel (Cororaton and Timilsina, 2014,)

Economic feasibility: Solar energy initial costs are calculated by the average prices of the equipment and once the initiative is connected to the grid, there is every possibility to receive subsidies from the government as part of the renewable energy policy for promotion (Romero *et al*., 2016).

Energy conservation benefits: The operational performance and the net annual electricity consumption of solar energy is far higher than the traditional system (Boampong and Brown, 2020). Solar energy panels are expected to last between 35-45 years after installation and without additional cost to the end users (Ma *et al*., 2017). Therefore, energy tapped and stored can be economically utilised for various purposes.

Socio-economic benefits: Creating and integrating solar energy policies to enable creation of millions of new jobs in communities has positive impact to the society (Naidoo, 2020,). Upgrading solar deployment to grid connections contributes to a broader value creation such as domestics and segment of the value chain (Mishra and Behera, 2016).

3.9 Summary of the Chapter

In conclusion, the chapter has discussed an overview of solar energy globally, the history of solar energy, types of solar energy technologies (PV and thermal) as commonly known in the industry, its sources and application in our day-to today's needs. The status of solar energy, its application, challenges and acceptability with policy strategies adopted in many countries including Sub-Sahara Africa was discussed. The few countries inculcated in this research are the United State of America, Spain, Japan, Germany, China, South Africa, Ghana, Kenya, Morocco, Algeria, Chad and Nigeria, which is the focus to compare how other countries mitigated the barriers for solar energy implementation. According to literature, by 2015, Nigeria has already proposed more than 58 solar projects within the six geopolitical zones and more than 200 solar mini-grids projects underway. 16 major projects have secured licenses to research, develop and deliver small and medium scale solar projects. Even though, the environmental analysis shows that Nigeria potentially possesses high strength for solar application and development. Literatures identified enormous factors that drive solar energy initiative in Nigeria. These includes the United Nation sustainable development goals (SDGs) demand for CO_2 footprint reduction, increased energy demand due to increase in population, power sector reforms laws, energy security, settling energy conflicts, job creation, local value, growth in education and technology, stakeholder's involvement, financing and market potentials in rural and urban communities. The literature also identified barriers that could hinder the successful application of solar energy which includes technical, economic, social, financial, institutional, and political, among others. Accordingly, the United States of America, China and Germany are the largest markets for solar PVs. Nigerian could emulate the developed countries to redefine strategies for achieving sustainable electricity in the country. It is therefore apparent to further

investigate the solar energy drivers, barriers and benefits in Nigeria. The Next chapter discusses the method of primary data collection and interpretation of the research.

CHAPTER FOUR

Research Methodology

4.0 Introduction

In this chapter, a research paradigm, design, approach, methods, qualitative semi-structured interviews have been identified and discussed. Data interpretation and analysis with content and ISM adoption have been discussed. Furthermore, framework development, evaluation and ethical consideration of the research have been discussed and the chapter is divided into six sections. The research methodology of the study directly impacts the strength and generalisability of the research (Habib *et al.*, 2014). It discusses the procedure that the research is conducted with a justification for the chosen approach. It therefore addresses the research method that is adopted to capture data required to achieve the research aim and objective.

4.1 Research Philosophies and Paradigm

A paradigm is a way of examining social phenomena from which understandings of these phenomena can be gained and explanations attempted (O'Gorman, 2016). Philosophical paradigm, which is sometimes referred to as a research paradigm, is known as the philosophy of a research. The research paradigm/philosophy, thus, offers a framework,

consisting of theories, methods, and ways of defining data, which explains the relationship between data and theory (Collis and Hussey, 2003; Davies and Hughes, 2014).

Every research is conducted to answer one or more research questions and the research methodology structures the path for doing so (Creswell, 2013). Meanwhile, the research philosophy is pivotal in portraying the researcher's standpoint against the research problem. According to O'Gorman, (2016), there are at least three reasons why understandings of philosophical issues are very useful. Firstly, it helps to clarify research designs. This does not only involve considering what kind of evidence is required and how it is to be gathered and interpreted, but also how this will provide good answers to the basic questions being investigated in the research. Secondly, knowledge of philosophy can help the researcher to recognise, which design will work, and which will not. It indicates the limitations of an approach. Thirdly, it can help the researcher identify, and even create designs that may be outside their experience. It may also suggest how to adapt research designs according to constraints of different subject or knowledge structures (Collis and Hussey, 2003). According to Holden and Lynch (2004), the concepts of philosophy must be considered to match the research approach and underlying philosophy; these are ontology, epistemology and axiology.

Based on the above assumptions, the philosophical assumptions underpinning this study are mainly interpretivism (a study that is hermeneutics in nature). Even though, the study has a foot-mark of other perspectives: post-positivism (an improved Objectivist bearing), and critical postmodernism (underlying the diverse views around the world on instructivist and

constructivist philosophies and the conventional practice positivist and interpretivist methods) (Ivey, 2013).

The interpretivist ideology approaches offer the researcher a wider scope to understand and address the issues that influence and impact, where questions such as ‘why’ and ‘how’ the power sector is tumbled down with a lot of issues making it unsustainable. The purpose of the interpretive approach in information science is to produce an understanding of the framework and the procedure where the information science is influenced by the context (Jackson, 2011). This justifies the researcher’s choice of hermeneutic philosophical justification for this study. Interpretivism discusses crucial matters of shared meaning and perception, whereas constructivism pulls the knowledge study as formed and construed. Therefore, interpretivist and constructivist are interrelated with direct correlation towards the outcome of the study. Under this philosophy, individuals construct their own information and perception, and therefore, the researcher placed within the parameter of constructivist epistemological discourse. Its emphasis that the reality of nature is socially constructive, and the learning atmosphere must be formed in such a way that there is an intimate relationship between the researcher and the case being researched, while the researchers express their exceptional individual practises in the research method (Crist and Tanner, 2003; Tuohy et al.,2013).

In this situation, the researcher, observes the environment, investigate the phenomenon, and understands the situation of the research methods and further conduct an in depth of documents that subtleties researcher’s experiences.

4.2 Research Design

A research design is a blueprint that describes the underpinning step by step process that is involved in carrying out a research from beginning to an end (Creswell, 2013). In other

words, it is a logical formation of an inquiry that ensures data collected via a foremost strategy, are adequate to stand reliable answers, and credible for an overall research question (Bryman and Bell, 2007). O'Gorman, (2016) expatiated that research design is the plan a researcher intends to use in carrying out investigation to provide answers to his/her research questions. Kirshenblatt-Gimblet (2006); O'Gorman, (2016) detailed designs prevalent in research literature as; identifying the qualitative design, quantitative design, mixed method design and triangulation design, sequential design, embedded design, design strategies; descriptive and exploratory study design.

From the various research designs discussed above, exploratory research design is found most useful for this research. This research design excavates into a problem that has not already been properly investigated (De Langhe and Schliesser, 2017). The justification for adopting exploratory research lies on the fact that the persistent and interrupted power supply in Nigeria has not been properly investigated. Whilst there are enormous energy options, only solar energy has small amount of deployment with limited records of the implementation process (Ehi-Uujamhan, 2016). Therefore, the researcher explored the best research design determinant, data collection methods, selection of sample size and analysis (Park, Na and Chang, 2016). The end purpose was to seek ways to uncover the cause-effect and relationship to the prolong challenges existing in the power industry. Perhaps the secondary data from the literature reviewed yielded findings, which need to be further investigated for a rich result that is further used to streamlined theme for strategic framework development that will proffer solution to the challenges identified. Figure 4.3 shows the process by which an exploratory research is conducted.

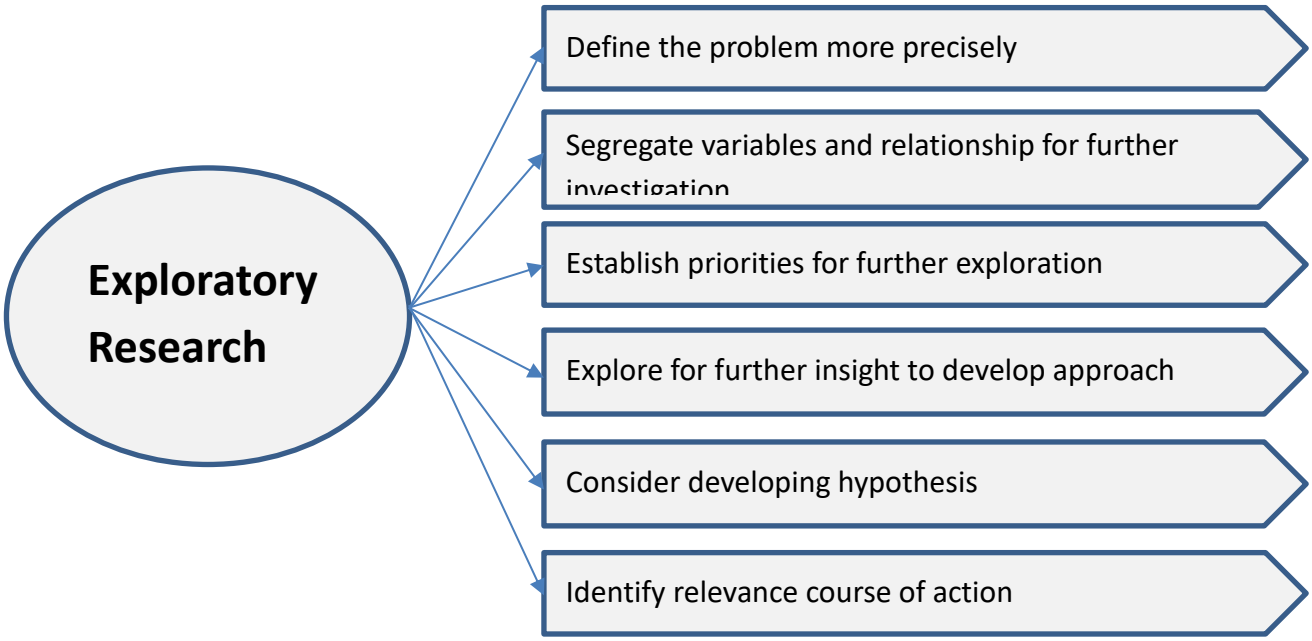

Figure 4.1 Exploratory research processes.

Source: adapted from Joseph (2014)

4.3 Research Approach

There are two important schools of thoughts with respect to methodology in the area of theory development and knowledge building. These are deductive and inductive research methods (Crowther and Lancaster, 2008). Deductive approach (top-down approach) as a logical process of reasoning usually begins with a general theory (what is known about in a domain) and moves toward inferring a more specific hypothesis which is subjected to empirical scrutiny against observations. Inductive approach, on the other hand (bottom-up approach) moves the other way around from specific observations towards detecting patterns and formulating some hypotheses to be explored, ending up in broader generalisations and theories (Trochim and Donnelly, 2008). Figures 4.1 and 4.2 shown below illustrate an overall view of each of these approaches.

4.3.1 Deductive Approach

Deductive approach is defined as a manner of reasoning whereby the conclusion of the investigation reasonably flows from the cautious evidence, intentions or expectations drawn from different existing theories (Saunders et al., 2012). Kumar (2014) further expatiated that the conclusiveness drawn from the deductive reasoning has been justified as factual, and all, the premise, understanding and proposition are also considered as fact. Even though, some scholars opine that the deductive reasoning defines itself to the domain of perceptive general research context (Snieder and Larner, 2009). This reasoning began with the process of identifying the underlying problem which leads to the development of a single or group of hypotheses based on a known theory that is subject to further empirical testing in the research finding that can either be upheld or rejected (Horn, 2010; Howitt and Cramer, 2010). Arguably, Burney (2008) considers the deductive approach as a logical process of reasoning on the view from general to more specific; widely known as top-bottom approach in the field of research. The researcher moves in stages and process, step - by step from theory, hypothesis, observation test and confirmation/rejection (Burney, 2008) below is a system diagram showing the reasoning process of deductive approach in research.

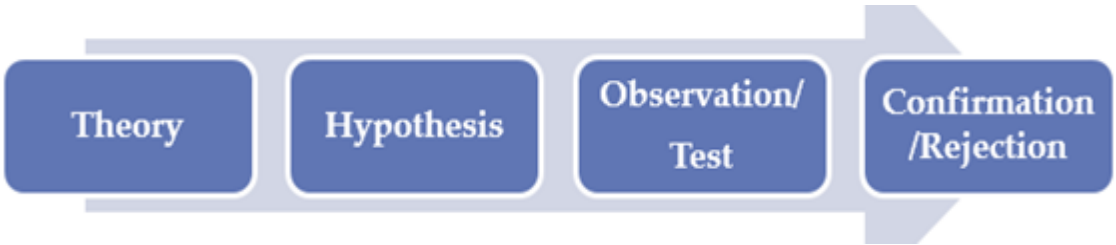

Figure 4.2. Transition of Deductive Approach in Research

Source: Burney (2008)

4.3.2 Inductive Approach

Inductive approach is a process of reasoning which begins with observation of the world first, then moves towards a systematic concept and generalisation about the phenomena that has already been observed (Neuman, 2014). In other words, inductive approach is a reasoning that ‘‘involves the search for pattern from observation and the development of theories for those patterns through hypothesis’’ (Bernard, 2011). The statement clearly explains how the inductive approach starts with distinctive issues, from which the researcher develops and generalises the reasoning, moving further to identification of relationship among the phenomena under investigation and finally ends the theory with the development (Saunders *et al*., 2012). Inductive approach begins with observation of the phenomena and ends with theory formulation which is contrary to the deductive approach which starts with theory development and conceptualising the theory into investigative narrowed phenomena reasoning.

Burnley (2008) and Lodico *et al*., (2010) summarised the inductive approach from specific to more generalised pursuit to find answers to an inquiry widely known as bottom-up approach in research. The researcher moves in chronological order from observation, pattern, hypothesis and to theory, critically considered as the reverse of the reasoning in deductive approach. Figure 4.3 is a clear diagram showing the three stages involved in the inductive approach in any social research intended for the building of theory.

Figure 4.3 Transition of Inductive Approach in Research

Source: Burney (2008): Lancaster (2007)

The researcher adopted inductive approach in order to have a holistic understanding of the research questions and to ensure that all the important aspect of the data is captured. The resources -text line was read by line, paragraph and segment thoroughly to capture the relevant information with correlation to the research questions. Furthermore, inductive approach enables the researcher to derive themes from raw data by grouping data that conveyed similar meaning from distinctive authors to a first-order category.

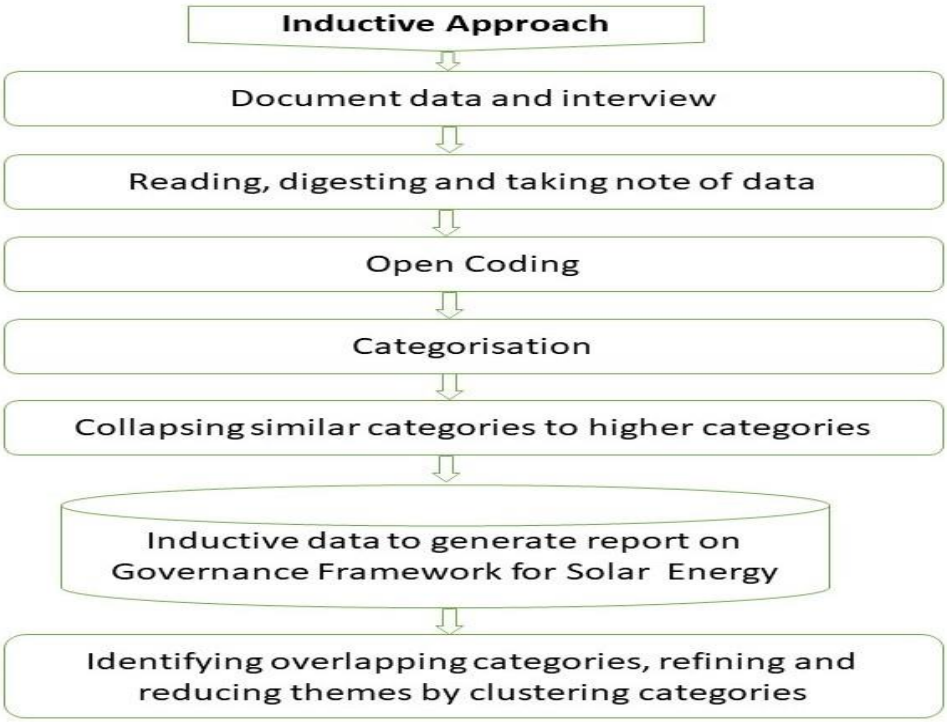

Figure 4.4 Organising inductive process

Figure 4.4 is a pictorial process of organising data in an inductive approach. The step-by-step, enable the researcher to source data related to the research question. The data are read, digested, and note taken to form codes, categorised codes to higher categories and generate an idea, identify an overlapping category to formulate a theme.

4.4 Research Methods

Data is collected from different sources using various methodologies. According to Creswell (2014), the data required can be classified as qualitative if it comes in descriptive form, while they are regarded as quantitative if they come in numerical format. The proper selection of quantitative and qualitative methods depends on the understanding of their application to the research context, which is vital to the success of the research in terms of presenting the phenomenon being studied. According to Saunders *et al*., (2012), the chosen research method can be any method of these strategies depending on the type of research questions and what is required for answering them.

According to Denscombe, (2014), methods are the instruments and processes for gathering research data, analysing it and drawing conclusion from it. A method is a systematic and orderly approach taken towards the collection and analysis of data so that information can be obtained from those data (Chandra and Sharma, 2013). Consequently, the term methodology refers to the theory of how research should be undertaken (Saunders *et al.*, 2012). Methodology is an explanation of why certain data is collected, what data is collected, from where the data is collected, when it is collected, how it was collected and how it was analysed (Denscombe, 2014). Therefore, the research methodology should address four main issues: what data are needed, where the data are located, how data are

obtained and how data are analysed (Leedy, 1997; Leedy and Ormrod, 2001; Chandra and Sharma, 2013).

A research methodology may be implemented through different research strategies, which is also known as a research plan or designs, the plan for conducting a study, through translating the research methodology into specific research methods, the technique used to collect and analyse data (Ahmed *et al*., 2016).

4.4.1 Quantitative Method

So many authors have defined quantitative research. It is defined by Creswell (2014) as an inquiry into a social or human problem, based on testing a hypothesis or a theory composed of variables, measured with numbers, and analysed with statistical procedures, in order to determine whether the hypothesis or the theory holds true. Creswell (2014) further stated that the investigator, primarily uses post-positivist claim for developing knowledge when the quantitative approach is adopted (i.e., cause and effect thinking, reduction to specific variables and hypotheses and questions, use of measurement and observation, and test of the theories), employs strategies of inquiry such as experiments and surveys, and collects data on predetermined instruments that yield statistical data. The use of experiments, statistics, content analysis, social survey and structured observation has been identified as quantitative techniques (Creswell, 2013). It has been noted by many authors that quantitative methods ignore social and cultural influences and assume a value-free and objective report). Additionally, it has also been pointed out that a purely statistical logic can make the development of hypotheses a small matter and can fail to help in generating theory from data (Picardi and Masick, 2014). Based on this shortcoming of the quantitative method, an alternative method of research that can explore the underlying “real world”

environment and to include the hard to define the factors which influence actual human behaviour (qualitative method) is usually proposed.

4.4.2 Qualitative method

According to Denzin and Lincoln (2005), qualitative research involves the studied use and collection of a variety of empirical materials-case study, personal experience, introspective, life story, interview, artefacts, cultural texts and productions, observational, historical, interactional, and visual texts that describe routine and problematic moments and meaning in individuals' lives. Patton (2015) defines qualitative research as "a form of systematic empirical inquiry into meaning". The word "empirical" in this definition implies that inquiry is grounded in the world of experience. According to Tracy (2013) the validity of generalisation in qualitative research does not depend on statistical inference, but on the plausibility and cogency of the logical reasoning used in describing the results from the cases and in drawing conclusions from them. Denzin and Lincoln (2018) argued that qualitative research involves an interpretive and naturalistic approach. It implies the researchers study things in their natural settings while trying to make sense of them and interpret phenomena in terms of the meaning people bring to them. The several types of qualitative designs found in the literature include ethnography, phenomenology, action research and grounded theory (Berg and Lune, 2014).

4.4.3 Types of Qualitative data

The qualitative data approach is widely used in research. Hence, five approaches are discussed below alongside their merits and demerits.

Table 4.1 Types of Qualitative Data Collection Approaches

Methods	Description	Merits	Demerits	Approaches
Structured Interviews	One-on-one interviews with predetermined questions	The type is easy to administer and quicker	Lacks depth and follow up for information	Phenomenology; Grounded Theory; Ethnography; Case Study
Unstructured Interviews	Unstandardised questions, can explore through open-ended questions	Allow follow up, more in-depth, open response, less rigid	Less consistency in collecting data, time consuming	Narrative; Case study; Ethnography; Phenomenology
Focus Groups	The researcher uses group interaction to formulate a case	Allow social context and multiple information on time	Limited questions, interference between discussant, a room for confusion	Phenomenology; Ethnography; Grounded Theory
Direct Observation	The researcher gathers firsthand data from direct observation and make notes	Research can gain holistic perspective by observing and can get some unexpected outcomes	Observation might affect participant, time consuming, data may be intrusive	Phenomenology; Ethnography. Case Study
Participant observation	The researcher fully participates in the observation; active observer	Active participation result of more understanding of the context, more natural and less intrusive	The participant may lose objectivity, the topic may be too close to participants	Ethnography. Case Study
Written Documents	The researcher depends on existing documents such as letters, diaries, memos, emails etc.	It is inexpensive, it provides factual data as records otherwise the data is unobtainable of there are deceased	Not easy to verify and validate data, data can be subjective on view of the writer	Narrative; Case Study
Artefacts	The researcher study items produced in the form of craft in different societies, culture for evidence	It proofs how people live, what they believe in and what they do as values, their opinion	Interpretation to some items can be difficult in meaning, concept and message	Narrative; Case Study

Source: Berg and Lune (2004); Creswell (2013)

4.4.4 Rationale for a qualitative study

Qualitative research is exploratory in nature because it methodologies allow the researcher to source for richer and more in-depth understanding of the phenomenon. The data are otherwise called first-class data that acquired a high percentage of reliability, credibility, and trustworthiness. This study is about why the research is needed, how the research is

conducted and whom the research is for. While other methods capitalise on the outcome of the investigation, a qualitative research method recognises the process and techniques that lead to the outcome of the investigation. It is also argued that when the understanding of an incident is a purpose of personal interface and the perception of those in the occasion, the description of the process that characterise the occasion, qualitative methods are more appropriate than quantitative methods. Qualitative approach is becoming more popular and widely used for methodology and analysis (Creswell, 2013). The process used in qualitative approach is best when applied in a complexed situation, to reveal perception, behaviours, and the interrelationship among peers in complicated dimension of a phenomenon.

Type of Data Sources

There are two types of data available for collection in any kind of research. The data can either be primary (Raw data) or secondary (second-hand data). Each data collection possesses a connection with what research is carried out and what data is needed for the investigation. In most cases, both primary and secondary data are collected to reach a saturation of the investigation.

Primary Data

Primary data: is a raw data or a data collected as a source primarily from a first-hand source that has not been collected or interpreted by a third party. This type of data is carefully obtained from, either by observation, survey, experimental and interviews (Wilke *et al*., 2017). The data are not subject to previous processing, manipulation, interpretation of any kind. Primary data can be collected through the following procedures:

Observation: The data collection under primary data collection method is widely used in behavioural sciences and social sciences. The observation is this occasion, is termed as the

scientific tool carried out by the researcher to get an insight into an investigation (De Langhe and Schliesser, 2017). The researcher formulates the method, the research purpose and systematically plans the process while considering the limitations and ethical consideration involves. When the observation is categorised by careful style of observer, under the condition of the observation, the observation is known to be structured (descriptive) and unstructured (exploratory) observation (Galliers and Huang, 2012). But when the observer is more or less part and participle of the observation; involved fully, the observer is a participant observer, while the opposite holds true when the observer is not participating in the group or incident under observation for non-participant observer (disguised observation) (Gibbs, 2002). In addition, if the observation takes place under natural setting its termed as uncontrolled (exploratory observation). When the observation is pre-arranged, with a prior setting to the observation, it is known as a central observation (laboratory participation) (Hartley, 2011). The method has an advantage of the data being recorded, eliminate subject to bias and the data can be free from past and future behaviour effect (Masuhara, 2015).

Interview: The method of data collection is a process by which data collection is conducted by oral, verbal presentation from an interview to an interviewee about phenomena. This method is widely used in the qualitative data collection because the interviewee can elaborate on the question to give an in-depth insight on the matter under investigation (McGuigan, 2011). The interview methods can either be personal face to face contact with the interviewer or a telephone interview using phone to ask questions and get responses from the interviewee where the conversation need to be recorded for further transcription (Marshall *et al*., 2013).

The personal interview can also be taken through the following seven (8) ways:

- **Direct personal investigation:** where the researcher has to collect data that are personally from the party concerned.

- **Indirect (Oral Investigation);** the researcher must cross examine someone who knows about the issue being investigated.

- **Structured interviews:** Interview that involved the interviewer pre-determining the interview process based on agreed and standardised recording tools and techniques (Cross and Galletta, 2013). The interviews, here are short, precise and clearly worded closed questions structured towards precise answers in a format presented on paper. This type of interviewing is considered easy in the process of administering it and it can easily be standardised because the same questions are asked of all participants. This type of interview is appropriate for a research which the goal is already clearly understood and specific questions can be specifically branded to suit the goal (Johnston, 2010).

- **Unstructured interviews:** This type of interview does not follow a protocol of predetermine procedure, it is flexible and allow the interviewee freedom to express their perception in more details (Cross and Galletta, 2013). The interview allows the interviewer to pose some open-ended questions and the interviewee to express his/her opinion freely. Both interviewer and interviewee are at ease in terms of freedom of expression, it is more like a discussion on a topic (Ketchen and Bergh, 2004). In this occasion, the interviews are not predetermined because is driven by the interviewer and the interviewee and making it difficult to standardise the interview across different interviewees (Denscombe, 2010). Nevertheless, it is possible to source rich data, information during the interaction and conversation

which varied to suit the framework of the interviewer to more deeply and specific issues that may arise. Contrary to the freedom and simplicity of this method, it considered time consuming, which every researcher would not want to venture into their research time frame and even more difficult to analyse at some point with large data.

- **Semi-Structured Interviews:** This type of interviews consists of almost the structured and unstructured interviews where both closed- ended and open- ended questions can play a role. It is widely used because of the advantage it has in employing both methods at the same time (Nguyen, 2015). It is normally predetermined with core questions for guidance in order to ensure all areas in the questions are covered with each interviewee. Galletta and Cross (2013) further asserted that interviewee gives an opportunity to elaborate and express freely to more information that might be deemed relevant to the research if they are freely willing to do so. This study adopted the semi-structured interview to enable the researcher source more in-depth information from the interviewees on the issues related to the power sector, solar energy challenges, drivers, mitigation of the barriers and the way forward to attain a sustainable solar energy in the country (Lancaster, 2007; Liamputtong and Ezzy, 2005; Khan, 2014).

- **Focus Interviews:** this kind of interview allows the interviewer to explore all sorts of techniques to ask the respondent questions about an experience the interviewee deemed to have about a phenomenon (Daniela *et al*., 2017).

- **Clinical Interview:** the interviewer tends to draw information from the respondent's point of emotion, feeling, motives, personal and individual lifestyle on a matter under investigation.

- **Non- direct Interview:** in this method, the interviewer motivates the interviewee to give more information by technically asking bare information indirectly.

Interviews are considered one of the best ways to get rich data from sources, even though, the method also has some merits and demerits just as any other methods (Nguyen, 2015). The merits of the interview include an opportunity for in depth information, control of the sample size, it is flexible, profile information can be obtained to backup information and errors and bias in misinterpretation can be avoided especially in unstructured interviews (Galletta and Cross, 2013).

On the other hand, the demerit of the interview is that, the method is expensive, the respondent and the interviewer can both be bias to the information, it is time consuming, the interviewer must apply high skills in the interview process and the interviewee response holds the main information needed (Creswell, 2013).

Telephone Interviews: this method, the researcher obtained information from the respondent via a telephone call, asking question and opinions from the interviewee. This method is flexible, cheaper, faster, higher rate of response, no field staff required. The method also has demerits; the interview restricts the respondent only to those with telephone, questions on this method must be precise and short and not enough information can be collected (Silverman, 2015; Saunders *et al*., 2015).

Questionnaire: In this method, the questionnaire is sent via email, hand to hand, online survey questionnaire like survey monkey and other online survey questionnaire

administration (Rowley, 2014). The concerned targeted responded is expected to read the questions, digest, and reply to the questions. One of the best ways to test the method is to conduct a prior pilot study where the researcher will design the questionnaires, administer them in order to figure any error before the main study questionnaire is prepared (Kumar, 2014). The quality of good questionnaires should be short, precise, simple terms, logical and sequential, control questions brief the respondent about the questionnaires, and the quality of the questionnaires must be good.

Delphi Techniques: This technique allows the researcher to elicit the information from a group of experts either personally (face -to -face) or via a questionnaire sent by an email. The questions are the same, but the opinions to what they perceived on the concerned questions from different experts are drawn and integrated to formulate an accurate answer (Holden and Lynch, 2004). The merits of the technique are that respondents can send back their answers simultaneously, saving time and cost. On the contrary, if the interviewer chooses to interview the respondent personally, it will result to a time consuming and costly (Denscombe, 2017).

Projective Technique: The technique is indirect and unstructured, where the interviewee is unwilling to give answers to the question in research because the objectives in the question are closed ended (Pazeley, 2013). The best way to deal with such situation, is to design and provide an incomplete spur through which the underlying motivation trigger the motives, opinions, feeling, attitudes of the respondent to detail their answers to the questions (Denzin and Lincoln, 2018).

Focus Group: Focus group is widely used in data collection method by many researchers, where the researcher organises a group of few people between 6-12 people to come together

and discuss a common issue being investigated (Daniela *et al*., 2017). It is aimed to get an insight and opinion of each member, deliberate on the question, and come out with unanimous decision which the research will take home as the outcome of the investigation. It is time saving, but has a disadvantage of bias decision as the discussion can be influenced by powerful (Denscombe, 2017).

Secondary Data

While the primary data are from face, hand source, the secondary data are gathered and recorded by someone else for current and future projects. The data can be used severally by different people, different interpretation, and purposes. The data are further reused in so many ways, time saving, financial saving and less hassle to obtain. The sources of secondary data can be further divided into two; internal and external sources (Blythe, 2016; Meijer, 2013).

Internal Sources: Internal sources of secondary data are widely used for marketing and promotion purposes. They include sales records, distribution reports, customer feedback, cost information, marketing records and customer targets.

External Sources: The sources for this type of data are regarded as economic and financial purposes and marketing activities. They include books, journals, magazines, libraries, newspapers and above all, the internet.

The secondary data is either published, printed, online, achievers, audio, video, pictures, images and many more. The unpublished include letters, diaries, work, biographies, few to mention (Meijer *et al*., 2013). The challenge with this data collection is the credibility of the source to ascertain reliability and if it is free from bias and accurate to be trusted. There is also a concern about the suitability of the data to be adopted and if the data was properly

captured the methodology, scope, and originality. The data might also be questioned for adequacy, but scrutiny of the data can help to narrow or wider the area of research (Wang, *et al*., 2016).

Literature Review

A critical literature review was undertaken during the first phase of this research. Basically, to compare the research idea with the existing knowledge, to check the viability of the proposed research (thus avoiding repetition), to learn how to develop an appropriate methodology, to suggest routes for advancing knowledge, and to help in refining the objectives and research questions (Fellows and Liu, 2003). The survey of the literature, specifically for renewable energy in Nigeria, Africa and the rest of the world with emphasis on solar energy and the policies for implementation, helped the researcher to understand the requirements, benefits and problems associated with implementing solar energy implementation. This literature consisted of a careful review of textbooks, specialist journals, newspaper publications, and electronic sources, and the secondary data gathered through these means provided the ability to make useful comparisons with the primary which would be collected.

In reviewing the literature, the researcher focuses on power sector reforms, challenges, drivers, and barriers for solar energy strategies in Nigeria to address the objective of the study.

Sample Frame

Lewis-Beck *et al*., (2004) opined that the sample frame, represent the tools and techniques which are employed to reach target elements in the population. It is a detailed model where the research could suitably draw it sample from the target population. Even though, the

sampling frame for solar energy stakeholders in Nigeria is in development stage because the initiative is new and only few projects are completed and many more under the work-in-progress stages.

Sampling Time

It is vital in every research for the researcher to consider paying attention to the sampling time, because the timeline is critical and need to be carefully planned to reach a target without compromising the researcher's or the corresponding targets busy time (Macfarlane, *et al.,* 2013). A well-planned sampling time would be able to consider how many times the researcher needs to collect the data from the respondents, how the researcher accommodates changes that can occur as un-foreseen circumstances, and the tentative date the researcher intends to go to the field to collect the data as well as the duration which the data collection will take to be completed as approximately (Meyer, 2001).

For this research, the data collection was conducted from a sample size of 25 key executives (See Appendix C) in the 20 major players in the Nigerian power sector associated with the solar energy promotion. Even though, 36 organisations were invited to participate in the data collection, only 20 out of the 36 gave an audience and accepted to be interviewed. The interview schedules were not easy because of busy schedules of the targeted interviewees. The researcher approached the interviewees severally to schedule and re-schedule dates and time for the interview. The researcher was able to accommodate face-to-face interviews within a period of 7 weeks (Early August- to- End of September 2017).

4.4.5 Mixed Method (Qualitative and Quantitative)

There has been much debate whether quantitative and qualitative approaches can be combined with social research. So many authors have put many arguments forward that the

approaches are so different in their philosophical and methodological origins that they cannot be effectively blended (Denscombe, 2014; Flick, 2015). Hannink, et al. (2011) maintained that quantitative data can be used as supplementary evidence for an interpretive study and that the adoption of both qualitative and quantitative methods offers a richer contextual basis for interpreting results. According to Denscombe, (2014), the combination of qualitative and qualitative can be complementary. The use of either quantitative or qualitative can have its own pros and cons. In other words, a less literal sense in social research considered the multiple methods as 'triangulation' which is a method that investigates a phenomenon to overcome issues related to validity and bias (Blaikie, 2000). The method arose on point of ethical consideration to confirm the validity of the process in using multiple sources of data to arrive with the rich result free from bias and ambiguity (Yin, 2003). Creswell (2003) further expatiated as a means of increasing the trustworthiness of multiple data after comparing the outcome and drawing a judgement finding. The differences between the two methodologies (quantitative and qualitative) are presented in Table 4.2.

Table 4.2 Quantitative vs. Qualitative Methodology

Approaches	Qualitative	Quantitative
Philosophy	Constructivist and Interpretative	Positivism and Rationalism
Research Nature	Inductive and Subjective	Deductive and experimental
Research Purpose	To quantify sample data and draw views, opinion for research interest	To understand the subject; attitudes, gauge, opinion and tendencies
Research Objective	To have insight, understanding of reasons and motivations of purpose	To determine cause, effect, relationship and generalise sample population
Setting hypothesis	Hypothesis are developed to investigate the questions and inductive is developed	Precise hypothesis is governed by the purpose and deductive is developed
Variable types	There is no independence variable, the study is concerned about phenomena without interferences	The independent variable is controlled and manipulated.
Data collection method	Observation, semi-structured, unstructured interviews, in-depth discussions, focus groups and discourse analysis.	Data collection is mandatory; closed ended questions, survey experiment and questionnaire
Research Design	Research design is specified before the start of the investigation.	Research design is flexible and develops throughout the investigation.
Data analysis	Data are non-statistical, in narrative or verbal format.	Data are summarised and presented in numerical format.
Validity and reliability	Determine via multiple sources of information	Determined through statistical and logical method
Sample frame	Small size to fulfil requirement	The sample population is large
Research Findings	Either exploratory or investigation, or both and is inconclusive.	Conclusive are drowned to build recommendation (Context – based)
Researcher's role	The researcher participates and become absorbed in the research setting.	The researcher is an objective observer who neither participates nor influences the research.
Strength	Findings can be built for guiding policy, data are transferable to more analysts, disciplinary standard is maintained for survey research.	It gives an inside into relationship and process, causes and direction, collect data on issues are that are burning and marginal data.
Weakness	Marginal issues are hard to have access to household. Wasteful if the large data are not put into use as its relatively expensive.	The findings are carried out by single individuals, not generalised. Due to lack of legitimacy, the findings cannot influence policy and the data cannot be made publicly.

Source: Lawson et al., (2008); Howe and McKay (2007).

The choice of qualitative method approach is being adopted for this research study, having considered the differences, strengths and weaknesses as presented in Table 4.1 as well as the philosophical and realistic reasons with the research objectives alongside the wide range of information to be acquired and to where the required data are to be collected and evaluated.

This study is mainly concerned with an in-depth understanding of the strategies for implementing solar energy initiative in Nigeria. In addition, the concept under investigation (the driving forces to the implementation, the benefit of end-users of initiatives and the challenges therein in trying to achieve the implementation) is open to a wide variety of interpretations and is context-dependent. Therefore, considering the overall discussion within this section, the most suitable method for the primary data collection is the qualitative approach because it is suitable to achieve the aim of this research (Maylor and Blackmon, 2005; Knight, and Ruddock, 2009): Masuhara, 2015).

4.5 Data Interpretation and Analysis

The orientation of this research is evolved around qualitative research method, which entails the use of qualitative approach, strategy, instrument to collect data. As mentioned earlier in the chapter, the data collected went through three stages. Stage one; is the review of literature to understand the perception of other scholars on the phenomenon and conceptualisation of the funding to build a method for the main data collection. The stage two is the main data collection is to complementary synthesised findings that are converted to research questions for further investigation. The outcome of the two is integrated design a strategic framework for solar energy implementation. The third stage is to evaluate the framework by disseminating the framework to the solar energy stakeholders for review on the process, input, output, and the way forward.

In qualitative research methods, most of the data generated from interviews are often analysed by researchers using one, two or more of the following analysis tools; Thematic Analysis (TA), Discourse Analysis (DA), Conversation Analysis (CA), Computer Assisted Qualitative Data Analysis (CAQDA), Grounded Theory (GT) and Content Analysis (Graneheim and Lundman, 2004; Sweeney, 2009; Howitt and Cramer, 2010; Person Education, 2010; Horn, 2010). Content Analysis (CA) was found more useful and was employed as a method for the data analysis from the interview responses that was sourced from 25 participants. This is the point of saturation as most of the interviewee was not providing new data other than what has been collected. Therefore, it's become apparent to use the 25 interviewees as the sample size for that data collection. The paragraph below discusses the content analysis adopted for this research.

4.5.1 Content Analysis

Content analysis is a method in research where the researcher studies documents, artefact, and piece of interpreting information sourced variously; texts, pictures, audio, video and animation to replicate the analysis in a systematic manner (Graneheim, and Lundman, 2004).

Historical Perspective and Development of Content Analysis

Content analysis is a data analysis tool developed in the twentieth century in the United States of America to help in the analysis of large contextual data, mostly quantitative from the mass media, radio and newspapers (Kondracki and Wellman, 2002). It was initially focused on quantitative data to fetch out how many times a word or phrase occurs in terms of frequencies, especially how many times a political party is mentioned on the media. Heydarian (2017) argued that the combination of quantitative and qualitative, manual and

computer- assisted in a single study has broken the weakness criticism of the partial content analysis and enhance the reliability and validity in any research.

Theoretical Background for Content Analysis

Content analysis has fundamental theories that determine the procedure for qualitative content analysis in any research. The determinants are as follows:

- The resources to be analysed is perceived embedded in the context of communication from the author, transmitter, subject matter, the contextual characteristics, and the recipient for which the research is targeted.

- The systematic nature of the content analysis is associated with rules, procedures, pre-formulated framework, theoretically underpinned, questions and coding rules of the gradual process breaking down the text into single units of analysis. The narrowed categories of the analysis oriented are known to be content analysis.

- The qualitative analysis does not disintegrate itself from quantitative analytical procedures but integrate same into the analytical process in a justifiable manner.

- The content analysis in qualitative study measures itself against the quality criteria and inter-coder reliability to achieve a demonstrable result similar from the extract (Krippendorf, 1980; Mayring, 2000; Graneheim and Lundman, 2004).

Goals of Qualitative Content Analysis

The goal of content analysis is to systematically examine and evaluate a communicative resource that is in recorded format. It is a system with broad family techniques that researchers can employ based on the suitability to their research substantive questions.

Krippendorf and Bock (2008) emphasise that a good qualitative content analysis most address the following questions.

How the data are defined, which data are analysed, what is the relevant context of the data, what is the limitation of the data analysis, what are the key things to be measured in the research, and what are the population samples for the qualitative data analysis. The simplest and most effective way to consider the unambiguity characteristics of content analysis is the text and word frequency weighing in a resource (Denscombe, 2017).

Type of Content Analysis

Content analysis is recently widely used in qualitative research approach and the common approaches are conventional, directed, and summative content analysis (Ilic, 2011).

- **Conventional Content Analysis**

The conventional content analysis is used together with study design aimed at describing a phenomenon with little existing theory is called for further investigation (Hsieh and Shannon, 2005). In this analysis, the researcher allows the categories to flow through data and to allow new insights to develop. The process of this analysis starts with reading data repetitively to try and attain engagement and gain a whole sense of the data (Kondracki and Wellman, 2002). The data is further reading word-to-word to drive codes by highlighting the exact words or phrase of text that appeared to have captured the key concept of the research (Patton, 2000). The researcher continues with making notes on the impression, thoughts and initial analysis, labelling of codes emerged and the codes are sorted into categories to form an organised meaningful cluster. The researcher can combine a few clusters from the categories and sub-categories to a smaller number of categories and form a hierarchical diagram for clearer view.

The conventional content analysis was adopted in this research and the research carefully started with annotation of note on field data. This was followed by transcription of the field raw data manually to micros words, words and phrases were coded, categories and sub-categories were developed, categories were synthesised in theme and the themes was developed to form the research findings (Hsieh and Shannon, 2005).

- **Directed Content Analysis**

A time, theories exist on about a phenomenon that is not fully completed or benefit from further investigation. The qualitative research might use directed content analysis approach to deductively to categorise distinction on the role of theory (Kondracki and Wellman, 2002). The essence of the directed content analysis is to evaluate or conceptually extensible theoretical framework of the research. Mayring (2000) asserted that directed content can predict variables of interest and the relationship between the variables to aid determine the initial coding scheme and the interference between the codes in deductive categories application. Even though, the directed content is considered some extent more structured than conventional content, the approach is based on pre-existing theory where the researcher began identifying concept and variables as initial coding before defining the operational categories (Denscombe, 2017).

- **Summative Content Analysis**

Contrary to Conventional content and directed content analysis, the summative content is a qualitative approach that tends to identify and quantify words and phrases for the purpose of understanding the conceptual use of the words (Duriau, *et al*., 2007). The analysis seeks for the appearance of a particular word or usage of phrase as to the manifestation and frequency, continuity beyond the word count to discover the underlying meaning of the words as perceived by the respondent (Kondracki and Wellman, 2002).

Limitations of Content Analysis

Whilst the content analysis is widely used in recent time, it cannot be totally disintegrated from weight limitations to its concept, theories, and applicability. The approach is descriptive to some extent and do not address the underlying motives for the investigation of questions; 'why and how'. The approach is limited to availability of materials, especially observation cases in media, other scenarios are more prioritise than others with poor justification (Hsieh and Shannon, 2005). Despite the limitation in content analysis as well as other methods of analysis, qualitative research approach share a broader philosophy, such as person -centeredness, and a certain open-ended starting point given more alternative options (Vaismoradi, Turunen and Bondas, 2013). Other options include thematic analysis, descriptive analysis, and Interpretive Structural Modelling (IMS) (Sundler *et al*., 2019).

4.5.2 Interpretive Structural Modelling (ISM)

Interpretive Structural Modelling (ISM) is defined as a process aimed at assisting the human being to better understand and clearly recognise what one does not know (Farris and Sage, 1975; Singh *et al*., 2018). It is a popular and well-established method for recognising relationships within elements that define a problem (Abuzeinab, Arif and Qadri, 2017). In other word, it is an interactive learning process where a set of different and direct related elements is structured into a comprehensive systematic model (Raut *et al*., 2018. ISM, 'I' (interpretive) is the outcome of judgement, 'S' (structural) is the outcome of a set of variables and 'M' (Modelling) is the graphical presentation of the relationship of the overall structure (Khan and Haleem, 2015).

Application of ISM

The successive steps of the ISM are applied to investigate the interrelationships and interactions between the barriers for solar energy implementation. This includes Structural Self-Interaction Matrix (SSIM), initial reachability matrix, level partitions and formulation of ISM – based structural model (Farris and Sage, 1975; Jha, Aggarwal and Singh, 2009; Khan and Haleem, 2015; Abuzeinab, Arif and Qadri, 2017).

Structural Self-Interaction Matrix (SSIM)

Based on the opinion of high -profile management and stakeholders of the solar energy in the country, SSIM was formulated where four (4) symbols are used to denote the relationships between the barriers in the form of (***i*** and ***j***) as follows:

V: Barrier *i* will motivate to achieve barrier *j*;

A: Barrier *j* will motivate to achieve barrier *i*;

X: Barrier *i* and *j* will motivate to achieve each other and

O: Barriers *i* and *j* are not related.

Reachability matrix

The reachability matrix is created from the SSIM in the form of binary digits with ‘zeros’ and ‘ones’. Where A ‘o’ indicates that there is no interrelationship between the chosen barriers. On the other hand, ‘1’ indicates interrelationships exist among the barriers (Jha, Aggarwal and Singh, 2009). The ‘V’, ‘A’, ‘X’, and ‘O’ values are filled according to the following rules:

a. If the cell entry (i,j) in the SSIM is denoted by V, then the corresponding entry (i, j) in the reachability matrix became 1and the entry (j, i) is 0.
b. If the cell entry (i, j) in the SSIM is presented by A, then the cell entry (i, j) in the reachability matrix is 0 and the entry (j,i) become 1.
c. If the cell entry (i, j) in the SSIM is mentioned as X, then the cell entry (i, j) in the reachability matrix becomes 1 and the cell entry (j,i) also become 1.
d. If the cell entry (i, j) in the SSIM is given as O, then the cell entry (i, j) in the reachability matrix becomes 0 and the cell entry (j, i) entry also becomes 0 (Jha, Aggarwal and Singh, 2009; Jasti and Kota, 2020 and Diabat, et al. 2013.

Level Partitions

This is the level where the reachability matrix is partitioned into various levels based on three (3) sets, namely, the reachability set, the antecedent set, and the intersection set (Bhosale and Kant, 2016). The reachability set for a particular barrier consists of the barrier itself and the other barriers that it may motivate to achieve. Similarly, the antecedent set consists of the barrier itself and the other barriers that may be motivated in achieving it. Thirdly, the intersection set for each barrier is obtained from the intersection portion (common barrier) of the respective reachability and antecedent sets (Kannan, Diabat and Shankar, 2014).

ISM Based Model

The structural model for the barrier level is generated from the final reachability matrix. The existence of the relationship between i and j is indicated by pointing of an arrow in j and i (Singh and Gupta, 2020). Thus, the pictorial representation mentioning the hierarchical level is the digraph, hence, the digraph is converted into ISM model where the

transitivity is removed (Abuzeina, Arif and Qadri, 2013). The digraph represents the variables in the matrix which are interlinked together in terms of relationship with arrow direction from one node to the other (Khan and Haleem, 2015).

Advantage of ISM approach

1. It is a systematic process that can computerised a pairwise relationship of an element either directly from the participants or transitive inference.
2. The process is simple and efficient without requiring a thorough knowledge of the underlying process for series of rationale queries.
3. It produces structured graphical representation of the scenario that can easily be communicated effectively and efficiently.
4. It encourages issue analysis by allowing the user to explore the adequacy of the proposed list of systems indicators for illustrating a specific situation.
5. It is a learning too that allow the user to develop a deeper understanding and significance of specific relationship within variables.
6. It aids in assisting the user in identifying a particular area for policy formulation and action plan for a specific objective (Khan and Haleem, 2015; Sivaprakasam, et al. 2015; Sun, Xu and Jiang 2020).
7. The ISM method in this research has defined the relationship among the barriers, as such, the Nigerian solar energy stakeholders can prioritise the most challenging barrier to be addressed, among others.

Limitations of ISM approach

Interpretive Structural Modelling (ISM) just the same as other methods is associated with limitations. An increase in the number of variables to a particular scenario can lead to a complexity of the method and therefore the size of the elements to be analysed is limited

(Khan and Haleem, 2015). In the application of the ISM method, the expert determines the driving and dependence powers of the variables being examined by the method (Lather and Kaur, 2019). The ISM method can be replaced with Structural Equation Modelling (SEM) which is also commonly use to ascertain the relationship linear structure (Khan and Haleem, 2015). The analysis of ISM is explained in chapter 7 of this thesis.

4.5.3 Framework Development

To accomplish the research methodology, a framework was developed to integrate the research findings from a literature review and field work data, as stipulated in research objective seven. The framework summarised the findings in diagrammatic format for easy reading and understand in lays man's term.

4.5.4 Framework Evaluation

To ascertain the reliability of the framework, the framework was evaluated by further interviewing the stakeholders who is initially participated in the fieldwork data. Ten volunteers from the solar energy stakeholders across the country were contacted, and six out of the ten volunteered to participate in the research framework evaluation (See Appendix F). A telephone interview was conducted throughout the evaluation period, where the conversation was recorded, transcribed, and analysed by content analysis. The framework worthiness, reliability, usefulness and importance were evaluated by the stakeholders.

4.5.5 Research Evaluation: Trustworthiness of the Research

Assessment of the accuracy in qualitative research outcomes is not easy to be justified, but several strategies can be used to ensure the trustworthiness of the qualitative findings. Trustworthiness is the extent to which the data collected and analysed are believed to be

measured in terms of quality and trustworthy (Creswell, 2013). They further suggested that the qualitative research data trustworthiness can be measured, and justification can be established based on using four strategies; transferability, credibility, conformability, and dependability which are constructively parallel to external and internal validity, reliability, and neutrality. The researcher takes cognisance of the argument with consideration to the fitting and related to this study as discussed herewith (Redmond and Griffith, 2003).

Transferability

Transferability is like external validity whereby the extent to which findings can be generalised or transferable from actual to new contexts. However, the researcher is challenged in transferability because the research is subjective to the instrument used in collecting the qualitative data and is somehow considered as threat to valid inferences in the traditional thinking of a research data (Ide, 2014). Even though, the threat can be reduced, by means of which the researcher detailed research methods, design, context and assumptions underpinning the study. The research is carefully sensitive and courteous to biased throughout this study from interpretation of literature through the analysis of the qualitative data. At the end, the generalisability issues must be resolved by the reader of the research outcome based on the closed context to the researchers' context (Thomas and Magilvy, 2011).

Credibility

Credibility in qualitative research is believed to an extent where the data is considered trustworthy and free from bias. Credibility is parallel to external validity with the assumption that the findings from the research match reality, and reality is related to meaning of people hypothesis within a social context (Cope, 2014). Mostly, it is up to the

reader to read, understand and judge upon the credibility of his/her presumption on the research study. From the interpretive perspective, understanding of the research is co-created without objective reality of what the outcome of the study can be compared justifiably. Therefore, the insertion of associate to ascertain into the research finding, feedback about the outcome, the interpretation and inference gathered from the participants is an increasing credibility of the research data (Ide, 2014).

Confirmability

Confirmability is the situation whereby the research findings can be as certain and conform corporately by others. It is objectively the extent to which the researcher conforms of account for various individual's bias and subjectivity (Redmond and Griffith, 2003). It is also considered as audit of the research in order to establish confirmability for the process and methodology by which the study is critically carried out (Cope, 2014). It is in this order, therefore, the research needs to critically and carefully collect rich data in a well-organised retrieval manner, so that it can be interpreted and made readily available to the researchers if the finding is suitably challenged in the area of research (Thomas and Magilvy, 2011).

Dependability

Dependability occurs when a reliability, consistency in observing some findings under similar situation is replicated with similar subject and similar context. It underscores the importance of the researcher accounting for the changing context and situations that are essential to the consistency of the study outcome (Guest *et al*., 2012). The dependability of this research is the process which the research followed; qualitative study methods and evaluation in integrating the literature reviews and the face- to- face findings to develop a strategic framework for solar energy implementation (Cope, 2014).

Reliability

In any research, reliability test is almost impossible due to human behaviour which is not static; it is continuously changing with factors that influence it (Noble and Smith, 2015). To assess the reliability of a study findings, the professionals make judgement about the soundness of the research process in relation to the application of appropriate of the methods employed (qualitative) and the integrity of the final discussion (Leung, 2015). Qualitative research is questioned and criticised with lack of adequate scientific rigour with poor justification of the method adopted, inadequate transparency in analytical process the findings are being collected in opinion which is subject to researcher bias. Therefore, the qualitative research reliability can only measure the consistency in which the result of the data is collected rather than scientific measures (Ide, 2014).

4.6 Ethical Consideration

In the context of research, ethics refers to the suitability of the behaviour of the researcher in relation to the rights of those who become the subject of the work or are influenced by it. Cooper and Schindler (2008) define ethics as the "norms or standards of behaviour that guide moral choices about researchers' behaviour and relationships with others". Ethical principles were applied in this thesis in order to prevent ethical issues, because people were involved in interviews and the researchers' behaviour with them was important. Participants were assured that their information is kept confidential, they have the right to withdraw at any time and everything is with their consent, there is no deception, and they were informed about every single step. Ethics application was approved by the University of Wolverhampton before the actual data collection started. This is to conform to Creswell (2013) who emphasised that the researcher has an obligation to respect the rights, needs, values, faith and the desire of the informant who voluntarily is giving the information. They

are several issues to be considered when collecting and analysing data to caution the researcher to be aware of the issues before, during and after the data collection process. Some of the issues are discussed below.

- Harm and risk (whether the study can hurt the participants directly or indirectly)
- Privacy, anonymity and confidentiality (would the study intrude to behaviour)
- Informed consent (whether the participant knows fully what the researcher involved)
- Honesty and trust (is the researcher honest in data presentation and interpretation)
- Voluntary Participation (to participate in the research is completely voluntary where the participant can continue or opt-out at any point in time).

According to Silverman (2011), researchers need to pay good attention on the relationship between the researcher and the participant during the interview process in terms of values, norms, and the cultural aspects. The ethical aspect, especially the cultural sensitivity is always an unexpected concern that occurs during the research interview process. It is, therefore, apparent, some proper steps be taken to adhere to strict ethical guidelines to enable the participant uphold privacy, dignity, confidentiality and anonymity. The research has followed the steps below to address the ethical issues to conduct this research:

i) Harm and Risk

The researcher made it clear to the participant that they are guaranteed a research that does not involve any harm, before, during and after the data collection (Koocher, 2014). It is apparent to clear the air to the participants regarding the probability of physical,

psychological, social, legal, environmental, and economic risk of harm that might occur because of participating in the research (Cope, 2014). The researcher assured the participants that the research is risk free from any harm of whatsoever.

ii) Privacy, Anonymity and Confidentiality

The researcher ensured that all the data collected including the profile of the respondent, the organization's role, administrative structure, and strategies are confidentially kept and in anonymity is maintained (Piper and Dutton, 2010) Any identifying characteristic is removed after the data is transcribed, analysed and disseminated as the content of the introductory letter to the organisation to ensure specified strict adherence (Noble and Smith, 2015). The researcher made it clear at the beginning that participant name, role or organisation would not be published or used for any other purpose to reveal their identity.

iii) Informed Consent

The researcher informed the participant of the nature and purpose of data collection method prior to the commitment of the participant in the data collection exercises (Scales, 2013). The research needs to obtain consent by writing to the participant early enough, to allow them time to ponder on decision to either participate or opt-out the request. The writer explains in detail, typical roles face-to-face interview, the recording aspect and expected duration of the whole interview (Miller and Wertheimer, 2010).

iv) Honesty and Trust

Honesty refers to moral character the researcher entrusts and connotes to positives virtuous attributes in adhering to strict ethical guidelines. The standard about honesty and

trustworthiness of the data collected and the accompanying data interpretation maintained sincere facet for good standard (DeMauro, *et al*. 2014).

v) Participation Right (Voluntary)

The research clearly informed the participant about their research and the purpose for which it is carried out (academic purpose only), the participation is completely voluntary. Therefore, the participant owns their legal right to participate and withdraw at any point during the research process (Miller and Wertheimer, 2010; Piper and Dutton, 2010).

4.6 Chapter Summary

This chapter presents the research philosophies adopted to achieve the underpinning research aim and objectives. The research process, methods, methodology and the rationale for choosing the qualitative method, content analysis and Interpretive Structural Modelling (ISM) for the data analysis have been discussed. The face-to-face semi-structured interview for the primary data collection and the framework evaluation interviews have been discussed. In this chapter, the ethical consideration requirement for the research and limitation of the research have also been presented. The next chapter (Chapter Five) gives details of the primary data collection, interpretation and analysis on the Nigerian power sector challenges and reforms.

CHAPTER FIVE

The Challenges of the Nigerian Power Sector

5.0 Introduction

Leveraging on the preceding methodology chapter four, this chapter interpret and analyse the data collected through qualitative semi-structured interview. The chapter focusses on the key challenges that led to the incapacitation of the power sector development in Nigeria for over 124 years of its existence. The power sector in Nigeria has undergone a series of reforms over the years and the underpinning effort to overcome the power outage and the collapse has resulted in a socio-economic slowdown in the country. The results are based on the response of the 25 interviewees who participated in the study and the substantiated findings from the literature reviewed.

In order to capture the understanding and perception of the experienced stakeholders on the issues associated with the power sector development in Nigeria, the following question was raised: *What are the key challenges of the Nigerian power sector?* The investigation reveals that the challenges as shown in table 5.1 below.

5.1 Key challenges associated with power sector development in Nigeria.

The Nigerian power sector stakeholders who participated in the study have identified seven key challenges responsible for the ongoing failure of the Nigerian power sector to provide adequate electricity supply to both domestic household and industrial needs. The challenges are presented in table 5.1.

Table 5.1: Key challenges for power sector development in Nigeria (N=25)

S/N	Challenges	No. of interviewee cited (N=25)
1.	Inadequate long-term sustainable policies	23 (92%)
2.	Lack of security and surveillance for power infrastructure	20 (80%)
3.	Corrupt practices and diversion of power sector funds	19 (76%)
4.	Monopoly and lack of country's energy diversity	18 (72%)
5.	Lack of customer's satisfaction in billing and disconnection	16 (64%)
6.	Lack of modern technology monitoring and communication	15 (60%)
7.	Lack of technical knowledge and maintenance culture	14 (56%)

5.1.1 Inadequate Long-term Sustainable Policies

92% (23 of the 25) interviewees argued that the root of the Nigeria power failure is due to poor policies and lack of implementation. The power sector lacks working mechanism, policy guidelines for energy mix and power sector development framework to check the affairs of the industry. The National Electric Power Authority (NEPA) and the Power Holding Company of Nigeria (PHCN) failed to develop a strategy for electricity diversification and public private partnership (PPP) to attract investors prior to 2003 as noted by interviewee A1 below:

> *''Is power generation not the sole responsibility of the government, and do the Nigerian citizens also have a role to play in ensuring steady power supply? The answer is yes. However, it is also the duty of the Nigerian citizens to practice the energy efficiency and conservation in order to go a long way in saving electricity and ensuring steady electricity, but this can only work when electricity policies such as tariff are favourable to the citizens and not the government alone''.*
>
> *(Interviewee 'A1').*

''The industry collapsed because the policies were not proposed to be implemented, they were strategies to distract the attention of the Nigerian citizens from knowing what is happening in the electricity industry. There was no control, monitoring, checks and balances, financial tight to budgets and auditing and therefore everyone does what they did to successfully drain the whole system to where it is now''. (interviewee 'K').

''Most of the policies proposed and enacted laws 1896 are considered short-term because they were less than 10 years and weren't made with population growth indices, for instance the policy formulated when the population was 40 million cannot work for a population of 80 million and this goes on to where the country's population is just less than 200 million in 2018''. (Interviewee 'N').

The interviewee highlighted the root cause of the decaying infrastructure of the Nigerian power sector linked to poor policy formulation. The interviewees further argued that the power sector system is weak in terms of monitoring and evaluation of its activities. The inability of the Nigerian government to design a long-term policy framework for the power sector is the result of the electricity infrastructure deteriorating to an absolute state. As a result, many industries are either folding off or relocating to a neighbouring country for the search of power and cheap labour in recent years. An example of these includes the Kano Sharada industrial estate, Kaduna textile industries and Zamfara textile industries (Sambo 2012). Therefore, the Nigerian government together with private investors need to

formulate long-term policies which will ago side-by-side with the Nigerian population demand for electricity access.

5.1.2 Lack of security and surveillance for power infrastructure

Nigeria has a land area of 923, 768 km^2 and a population of approximately 204 Million people and most of the electricity sources are thermal, gas turbine and hydro. The turbine stations are powered by gas, which is usually transported from far distance and most of the time reaching the destination cannot be guaranteed due to dilapidated road network and insecurity. The electricity transmission lines are drawn from hundreds of kilometres away, passing through dangerous and more vulnerable zones for vandals and cable thieves.

80% of the interviewees (20 of the 25) argued that the challenges of the power supply in Nigeria are linked to lack of security, surveillance, and transmission protection. Gas supply currently accounts for 75% of the installed power infrastructure in Nigeria. The gas supply is affected by the challenges associated with insecurity, theft, gas flaring and gas diversions as noted by the interviewees ('A2', 'B' and 'D'):

> *''The Nigerian transmission and distribution network are outdated with inexperienced staff, inadequate redundancy as opposed to the required network management, frequent vandalism of electric high-tension cables associated with lack of monitoring surveillance and security protection of electricity infrastructures''. (Interviewee 'A2').*

> *''The supply of gas to the nation's power plants has been affected by the insecurity challenges in Nigeria, especially the Northern part where contending violence has been in the rapid increase affected almost all the*

host hydro power plants in the country, while in the South the thermal plants face serious vandalism intimidations of gas pipes and disruption of movement of oil tankers that transport the gas to various power pants destinations. Even though, the shortage of gas at various refineries is also another connected challenge that is not controlled by the power sector and its agencies''. (Interviewee 'B').

''Since the power output of hydro plants is dependent on the water level, with less water, there is less potential energy to harness. Besides the issue of climate change lies seasonal droughts which also affect electricity generation from the large hydropower in Nigeria. The Kainji, Jebba and Shiroro hydropower plants are long overdue for rehabilitation and the actual energy output is below projected capacity''. (Interviewee 'D').

The interviewees lamented that the power sector challenges include the supply of gas from its source to power plants across the country. They also asserted that the challenges include insecurity, where electricity cables are stolen, distribution of gas and material are diverted, and electricity theft through illegal connections practices. Nwanakwere and Uzoeto, (2019) argued that lack of insecurity is a challenge not only to the power sector but also for any business establishment in the country. One of the interviewees expressed concern that the electricity could be challenged by weather, especially during the dry season when the dam dries off and the water level reduces. The government needs to review the status of the electricity supply to mitigate these challenges.

5.1.3 Corrupt practices and diversion of power sector funds

The Nigerian power sector has suffered the backlash from the financial misappropriation and diversion of funds meant for power sector plants and infrastructure development. 76% (19 of the 25) of the interviewees perceived that the power sector has been associated with corruption for a long period of time, as a result, power plant machineries are dilapidated, worn-out and obsolete to a state of low output.

> *''Money laundering, embezzlement, bribery, illegal oil bunkering, theft of intellectual property and piracy, open market abuse and diversion of monies allocated to the ministry for power for development projects, is a daily practice in the power sector'' (Interviewee 'Q').*

> *''We are made to believe and respect our fellow senior bosses in the office in order to remain as a staff, we watch the corruption eat up the organisation, but we have little or no power to stop it because we don't want to lose our jobs. This is something going on here ever before, we were born and employed, so I hope the government policies are changed to knock the system and break the chain that stopped the industry from making progress''. (Interviewee 'P').*

> *''It is on records that every year, huge amount in $billion dollars is budgeted and another $million dollars are sourced from international organisation to support Nigeria in an effort to restore uninterrupted power supply that is slowing the economic growth, but we are bewildered*

that the money is shared within few individuals and it is never judiciously accounted for''. (Interviewee 'G1' & 'F').

The interviewee noted that the Nigerian power sector is among the top government parastatal with highest financial budget, sadly, this sector has not made any significant improvement in infrastructure and new development. Nane, (2012) argued that the Nigerian power sector falls within the definition of corruption by the Economic and Financial Crime Commission (EFCC). The interviewees also argued that, there are other corrupt practices beside the financial misappropriation, which include inappropriate human and capital development sourcing, huge contract scams and project abandonment. Corruption perpetuates social-economic and political inequality and thus, aggravates mass poverty as poor people pay a higher proportion of their income to bribe their way up for employment in the power sector. The Nigerian power sector needs a total overhauling to effect changes in the infrastructure and have a framework for leadership and management of its assets.

5.1.4 Monopoly and lack of country's energy diversity

72% (18 of the 25) interviewees argued that the entire system was hijacked by the government as the private sector has been denied an opportunity to participate in the generation, transmission, and distribution of the electricity. The remaining 28% (7 of the 25) interviewees argued that the Nigerian power sector is predominantly challenged with monopoly; inability to share the responsibility of the power to the three tiers of government; federal, state, and local government. The interviewees noted:

''Nigerians are forced to accept the domination of the government in the generation, transmission and distribution with all the regulations, laws and policies formulated by the government and strictly vested to the

consumers such as tariff, cables and pools siting, transformer sitting and installation, overhead and overbuilding cables and other environment potentially hazardous installations''. (Interviewee 'E').

The assertions by the interviewees noted that the Nigerian government over the years, prohibits any form of generation, transmission, and distribution of electricity by private own individuals. It is concluded from the interviewee's point of views that the power industry was wholly owned and managed by the government for a long period of time. Olukoju, (2004) argued that the monopoly has contributed to the collapse of the Nigerian power sector and it is hoping the private investors under the PPP would take action to restore hope for stable electricity in the country. Both literature reviews and interviewees strongly agreed that the Nigerian electricity monopoly and lack of diversification has been one of the challenging factors before the privatisation in 2005.

5.1.5 Lack of customer's satisfaction in billing and disconnection

According to Arawomo (2017), the electricity consumers in Nigeria are in two categories: the consumers with metres and the consumers without metres. The consumers with metres are further broken to post-paid and pre-paid metre users. After the EPSRA was implemented, the new owners and agencies of the 11 distribution companies tried to ensure every household connected to the grids is fitted with pre-paid metres. Although, only about half of the electricity registered user's household are fitted with the pre-paid metres, leaving the remaining under arbitrarily charged by estimate basis. 64% (16 of the 25) argued that the Nigerian electricity consumers are unjustly treated with bogus bills and uninformed disconnections.

''We all know the distribution companies are under distress financially, but that doesn't mean the consumers have to take the burden by paying bills that are wrongly estimated in order to raise money to finance the overhead of the companies. It is the DisCo's responsibility to sources wherever they can and install metre to every electricity registered user so that justice can rein''. (Interviewee 'J').

''All the households that are yet to be metered continues to receive and pays exorbitant electricity bills to the distribution companies. Dates and time when the metres would be made available for installation remain unknown and the customers are therefore forced to bear the consequences for a wrong, they have not committed''. (Interviewee 'A1').

The interviewees perceived that the Nigerian electricity management has acted unjustly and unfairly to the end users by imposing high bills even when the supply of the electricity has been very low. Usman, 2013) reflects on the failed effort made by the distribution companies to minimise financial waste by metering all the registered electricity users connected to the grid. However, the debate between the metered and unmetered services for customers continues to raise questions. It is expected that the new ownership of DISCOs to metre all the grids connected customers to exercise transparency of the billing system.

5.1.6 Lack of modern technology monitoring and communication

64% (16 of the 25) of the interviewees noted that, lack of technology to monitor the usage of the electricity, such as metering, metre tempering, transformer tempering, and high voltage cable theft is a challenge that contributed to power supply interruption in Nigeria:

''Effort to survey, deliver and connect some communities to the national grid proves abortive because cables and poles laid down ready for deliver has disappeared overnight, no trace of who stole them, no trace of when that happens and obviously because its government property nobody seem to care'' (Interviewee 'B' and 'I').

An interviewee raised a concern that the Nigerian power sector lacks the technology to monitor services at the customers' ends. These include lack of modern technology to monitor equipment at stations, sub-station, industries, and households where services are distributed. They also lamented that electricity theft through illegal connection has become a daily business even for those that can afford to pay for the services. It is the responsibility of the distribution companies to monitor the services they provide to their customers and quantify the consumption of each consumer to avoid billing out customers wrongly.

5.1.7 Lack of technical knowledge and maintenance culture

The lack of technical knowledge and the inability to build a maintenance culture within staffing is a challenge that can lead to poor performance of the industry (Ohunakin et al., 2014). 56% (14 of the 25) interviewees noted that the Nigerian electricity has not kept up to standard for adequate maintenance of its infrastructure:

''Most of the plants and equipment installed in the major dams and thermal stations are more than 60 years old with no replacement, poor maintenance and not upgraded to modern energy facilities to uphold smooth running services for uninterrupted power supply''. (Interviewee 'K').

''Before 2005, the total installed capacity for generation stand at 8,000 MW but the total capacity that reaches the distribution station is just above 3000 MW, this is because the system paralleling the transmission to other components are inadequately functioning to transport the electricity to distribution station and to the end users. More than half of the generated power are lost on transport and electricity theft''. (Interviewee 'B').

Most of the infrastructure was originally designed for specific capacities, however, due to rapid and un-envisaged growth in population, most of the system's capacities has been exceeded and the lifespan is exhausted. The interviewees argued that most of the infrastructure for the Nigerian power sector has not been maintained satisfactory to work efficiently and effectively. Onoshakpor, (2014) argued that 62.5 % of the generated electricity is lost in transit as the infrastructures are mostly under obsolete condition. The Nigerian government and the generation companies need to design a system where electricity is generated to near where it is consumed to address the issues of electricity lost on transit and theft. This can be done by building mini-grids and standalone solar based systems to complement customers that are yet to be connected to national grids. All staff and management of the generation, transmissions and distribution companies would need to be trained. Section 5.2.1 – 5.2.5 is discussed in detail in section 5.3. In chapter 2 section 2.1 (Reforms of the Nigerian Power Sector) came first before 2.2 (Challenges of the Nigerian Power Sector) because the reforms formed part of the power sector development history and the later traced challenges that cause failure and call the need for investigation.

The result of the investigations prioritises the power sector challenges in section 5.1 and discussed the reforms in section 5.2.

5.2 Key Reforms for the Nigerian Power Sector

In an effort to addressed objective one of the research, the interviewees were consulted to respond to the question: *'In your opinion, what strategy and reform have been adopted to address the Nigerian power sector challenges'.* It is evident that the Nigerian power sector has undergone a series of reforms for over a period under the government ownership before the power sector reform Act implementation in 2005 and the responses are detailed below.

Table 5.2 Key Reforms for the Nigerian Power sector (N=25)

S/N	Key Strategic Reforms	No. of interviewee cited (N=25)
1.	The Birth of Electric Power Sector Reform Act (EPSRA)	24 (96%)
2.	The Birth of Power Holding Company of Nigeria (PHCN)	18 (72%)
3.	The Birth of National Electric Power Authority (NEPA)	16 (64%)
4.	The Birth of Niger Dams Authority (NDA)	15 (60%)
5.	The Birth of Electricity Corporation of Nigeria (ECN)	13 (52%)

5.2.1 Electric Power Sector Reform Act. 2005

96% (24 of the 25) interviewees considered EPSRA of 2005 as the best reform the government has ever made. The reform's objectives required that private individuals can now participate in the Nigerian power sector development under the PPP scheme and the power sector development can now be diversified into the energy mix. Prior to this time, the Nigerian electricity was under government monopoly with limited rights to the private sector. Two of the interviewees stated that:

''The private sector had no opportunity whatsoever to have participated in the power sector, everything was monopolised by the government. That

is why the industry failed to have sustainable electricity to service the country's demand on the electricity''. (Interviewee 'C').

''The private sector was denied participation, the industry was full of corruption and the recycling of corrupted management took many years, prevented entrepreneurs to come on board''. (Interviewee 'F').

It is a huge progress to unbundle the PHCN into generation, transmission, and distribution companies with almost 100 private ownership, except the transmission company which remains under the government entity. The progress is also recommendable for diversifying into the energy mix where solar energy development is making a huge progress.

5.2.2 The Birth of Power Holding Company of Nigeria (PHCN)

The Power Holding Company of Nigeria came to be being in 1999 but was made known to public as PHCN in the year 2000. An Act was enacted to establish the PHCN primarily known as an Initial Holding Company (IHC), as a strategy to regenerate the Nigerian power sector. 72% (18 of the 25) of the participant opined that the strategy was an effort made by the military government to privatise the power sector but ended up changing the name of Nigerian Electric Power Authority (NEPA) to the Power Holding Company of Nigeria (PHCN). According to the interviewees, the strategy has not yielded any positive change in the generation, transmission, and distribution and has not suggested any new idea to increase electricity access and mitigate power outage challenges:

''We were distracted with the Power Holding Company Name as it appears new to the customers with anticipation that this is an emergence

of a new electricity company, we will get changes in supply and tariff, the uncover to poor management and electricity depreciation was a shocker''. (Interviewee 'F').

It was affirmed by the interviewees that the PHCN has not made a significant change from NEPA to PHCN in management, power access, estimated bills and infrastructure development. Both literature and the interviewees perceived that changed of name from the National Electric Power Authority to Power Holding Company of Nigeria has not made any significant development. However, in 2004, the National Integrated Power Projects (NIPP) to catalyse and fast tract the upgrade of infrastructure with more additional capacity was inaugurated in the Niger Delta region due to excessive gas flaring and oil exploration in the area.

5.2.3 The Birth of National Electric Power Authority (NEPA)

64% (16 of the 25) of the Interviewees are familiar with one of the most popular brand names; the Nigerian Electricity known as NEPA. This was succeeded by the Niger Dam Authority (NDA) where the authority had a statutory function to develop and maintain an effective and efficient coordination of the generation and supply of electricity throughout the country. NEPA under its mandate can acquire land anywhere, anytime without exclusion of power to build, develop and execute infrastructure to increase electricity access. The authority has the power to discharge prices by issues of stock, borrow funds to execute power projects, scales the rates of tariff and to invest any surplus funds belonging to the authority without discretion of the ministry of power. However, the authority failed to diversify any strategy to move the power sector forward as noted by an interviewee:

''National Electric Power Authority (NEPA) existed for many years with dilapidated infrastructure due to lack of coordination and maintenance that resulted to poor transmission and distribution to consumption points where our consumers are left with no option than to buy petrol and diesel generators to get some electricity''. (Interviewee 'H').

''We haven't seen any change on whatsoever that we as consumers will have a thought, that the electricity is improving to meet the demand of a growing population. In some areas, the electricity is rationalised more than 12 hours off, 3 to 5 hours and so on''. (Interviewee 'J').

The interviewees perceived that NEPA was inappropriately managed with no evidence of monitoring, evaluation, and project auditing records. They further argued that the industrial infrastructure has been decaying for years due to lack of maintenance as a result, electricity access became limited as transmission and distribution has to be rationalised into hours.

5.2.4 The Birth of Niger Dam Authority (NDA)

The Act of the parliament established the Niger Dam Authority (NDA) in 1962, to take the responsibility for dam construction and the Kainji Dam was completed in 1968. The collaborated was formed to link Lagos, Zaria, Kano, Benin, and Kaduna as national grid connection. The Niger Dam Authority did not last for a long time before it was taken over by NEPA:

''NDA took over from the Electricity Corporation of Nigeria (ECN) as authority to expand and build more dams and link the grids to all regions. This failed because more than 70% of the Nigerian communities remained

unconnected to the grid and access to electricity was a challenge. Our parents and grandparents were using firewood for heating and cooking, kerosene lanterns and battery torchlight for lighting''. (Interviewee 'L').

The interviewee explained that the construction of Kainji dam and Shiroro dam was completed and the connection of grids began with less than 40% communities connected around the then 19th states. The grid connection has not increased or improved significantly to meet with the population growth in the country.

5.2.5 Electricity Corporation of Nigeria (ECN)

In the late 1940s, Nigerian government established a body to take control of the department of electricity supply known as Electricity Corporation of Nigeria (ECN). By April 1951, the then Native Authority (NA) which was responsible for electricity generation ceased to exist. The interviewees noted that, they knew little or nothing about ECN and the status of the power industry is evident that the early reforms of the Nigerian electricity did not play a significant role:

''From the way things emerged and where we found ourselves in the dark, it's a clear evidence that The ECN had little or no clue about the importance of electricity in socio-economic development, otherwise, they could have developed a 100-year long-term infrastructure for electricity generation and supply to every corner of Nigeria''. (Interviewee 'O').

The interviewees argued that the Nigerian electricity challenges are as a result of lack of long-term planning for expansion, diversification, maintenances and audit. The challenges

continue to exist within the power sector and the impact on socio-economic development is indisputable.

5.3 Summary

The chapter has addressed the first objective of the research to explore the Nigerian power sector challenges. The chapter explored the awareness of the key reforms and transitions the Nigerian electricity went through from when it was established in 1896 through 2019. The finding from the interviewees and the outcome of the literature review of the challenges of the Nigerian power sector as shown in table 5.3 below:

Table 5.3 Challenges of the Nigerian power sector (literature/interview)

S/N	Findings from literature reviews	Findings from the interviewees
1	Corrupt practices	Corruption practices and fund diversion
2	Gas dominated grids	Monopoly and lack of energy diversity
3	Lack of maintenance	Lack of technical knowledge and maintenance culture
4		Inadequate long-term sustainable policies
5		Lack of security and surveillance for power infrastructure
6		Lack of customer's satisfaction in billing and disconnection
7		Lack of modern technology monitoring and communication

From table 5.3 above, it is evident that more power sector challenges were identified from the interviews conducted. Therefore, the inferences and the implication could be documented for the challenges that hinder the development of uninterrupted power supply over a long period of time:

- Nigerian electricity has faced challenges with inability to have stable electricity supply to end users because the system lacks long term policies. The challenges have negatively affected the Nigerian socio-economic growth and development. Therefore, the new companies are tasked to come up with long-term policies to

support the generation, transmission, and distribution chain in order to meet the high demand of electricity in the country.

- Lack of security and surveillance has contributed immensely to the challenges face by the power sector. The Nigerian power sector is entirely conventional with a fraction of small - scale solar PVs across the country. The electricity is generated from limited sources scattered all over the country and transported across the six geo-political zones where 8.05% of the electricity is lost on transits between stations and sub-stations (Adebayo et al., 2020. Therefore, effort needs to be made to investigate the matter of insecurity, lack, surveillance and monitor the activities and affairs of distribution companies.

- The power sector was owned, managed and operated by the government with full ownership of infrastructure for generation, transmission and distribution. Opportunities were restricted to the private sector to participate in the power development except for very negligible top roof, solar panels for private homeowners, in the biggest cities of Lagos, Abuja and Port Harcourt. The power Sector Reform Act of 2005 allowed the private sector to own the licences for generation and distribution of certain fraction of electricity for household and small-scale businesses. Even though, the power sector was transformed to public private partnership in 2005, the power sector lacks track records of energy diversification. Nigeria can only optimise sustainable and uninterrupted electricity from other options like solar energy initiatives.

- Lack of technical knowledge and adequate training about the workability for electricity equipment and facilities is argued by many scholars and confirmed by

the power sector stakeholders during the empirical investigation. Operators lacks skills in practices and management expertise to run the electricity effectively. As a result, the infrastructure is mismanaged, overloaded, exhausted and vandalised to a dilapidated state. Stakeholders of the Nigerian power sector to review the human capital development regarding qualifications and experience, especially the technical knowhow on the facilities.

All these challenges have played a role in slowing the Nigerian power system to move from conventional electricity to a more robust user friendly and sustainable electricity from renewable energy source. While the challenges are discredited to the socio-economic development, they can also be classified as drivers for solar energy development in the country.

CHAPTER SIX

Key Drivers for Solar Energy Initiatives in Nigeria

6.0 Introduction

The preceding chapter discussed the challenges of the Nigerian power sector and the strategic reforms therein as an attempt to mitigate the challenges and increase the electricity access. This chapter tends to address objective two of the research where the first part has been addressed in chapter three through literature review and the second is addressed from field data. Therefore, the following question was asked to the interviewees. *What are the factors that fuelled the need for solar energy implementation in Nigeria?* The responses are shown in table 6.1.

Table 6.1 Key Drivers for Solar Energy Initiatives in Nigeria (N=25)

S/N	Key Drivers	No. of interviewee cited (N=25)
1.	Energy Mix Diversification Strategy	25 (100%)
2.	Synergy between Public and Private Sector	24 (94%)
3.	Lack of access to Electricity and Energy Demand	24 (94%)
4.	Electric Power Sector Reform Act. 2005	23 (92%)
5.	Government and Stakeholder's Commitment	22 (88%)
6.	Solar Irradiation Potentials	22 (88%)
7.	Institutional Policies for Energy Mix	20 (80%)
8.	Favourable Environment and Land Access	18 (72%)
9.	Market Competitiveness	17 (68%)
10.	Commitment to Achieve the SDG's Goal 7	15 (60%)
11.	Impact to Rural Economic Development	15 (60%)
12.	Job Opportunities and Employment Generation	14 (56%)
13.	Energy Saving and Efficiency	13 (52%)
14.	Feed –In Tariffs	12 (48%)

Although, in chapter three, the literature review has identified nine key solar energy drivers which include: sustainability, increased in energy demand, energy security access, neutralising energy conflicts, job creation opportunities, local added value, growth in education technology, stakeholder's engagement and financing opportunities and market. It was necessary to further investigate the factors that drive the country towards solar energy

implementation. The empirical data identified fourteen solar energy drivers (see table 6.1). The identification of further five driving factors for solar energy implementation of the empirical data is evidence of the research contribution. The drivers are discussed below:

6.1 Energy Mix Diversification Strategy

100% (25 of the 25) interviewees noted that one of the biggest factors that fuelled the need for the implementation of solar energy initiative in Nigeria is the advent of diversification from conventional electricity to the energy mix. According to Ariyomo (2014) the Nigerian electricity began in 1896, the generation remains exclusively thermal and hydro, except for few rooftops, private homes, solar PV in the big cities like Lagos, Abuja, Kano, and Port Harcourt. The interviewees reveal the following assertions regarding the diversification:

> *''The ministry of power is the pioneer of the entire power system in Nigeria and the driver for the EPSRA which lead to the unbundling of the PHC and NEPA and produced DISCOs, GENCOs and TCN. We are engaged in several solar power projects in Nigeria, projects in standalone system (SAS), centralised and decentralised mini grid systems. We have done battery charged projects in some villages across the country''. (Interviewee 'C').*

According to the interviewees, although the PHCN was unbundled to three companies, the federal ministry of power is still the apex stakeholder that approves the procedure, regulations and manner of generating, transmitting and distributing electricity in Nigeria. Among the MDAs responsible for the actualisation of sustainable electricity in Nigeria, the ministry of power is charged with the responsibility to examine and adopt viable strategies for energy mix. Some of the strategies are spelled in the vision 2020 and Vision 20: 2030,

which include standalone and decentralised mini grid systems all over the country. It was also noted that, the energy mix can serve as a recovery plan for energy access and reconstruction of the energy infrastructure.

> *''We draft the laws, regulations, roles for the generation, transmission and distribution of electricity be it from gas, solar, biomass hydro or any other form of energy in Nigeria. We were at the forefront of the power sector reform, which was a strategy to diversify the power sector into the energy mix''. (Interviewee 'D').*

The interviewees noted diversification as the best option and solution to the Nigerian power outage. Most of the stakeholders interviewed focuses on the importance of privatisation of the power holding company of Nigeria (PHCN), which allowed the private sector to invest and work along with the government to achieve the EPSRA objectives. Other interviewees further asserted that the diversification to renewable energy and privatisation of 60% of the power holding is a clear indication of the government commitment to the realisation of sustainable electricity. This coincided with the view of Aliyu *et al*., (2015) that the diversification to energy mix was overdue. They added that, the government commitment extends to all the stakeholders to support passionate entrepreneurs for solar generation, promotion, marketing, trading and installation in terms of subsidies, waivers to duties, financing sources regulations and environmental access to lands. Furthermore, the EPSRA 2005 and the diversification into the energy mix and solar energy is one objective of the reform with an indicator towards the achievement of vision 2020 and vision 20 20 30.

6.2 Synergy between Public and Private Sector

96% (24 of the 25) interviewees are in the view that, the relationship between the private and public sector towards generation, transmission and distribution of solar energy initiative has fuelled the process for solar energy implementation in Nigeria. Thus, the interviewees noted:

> *''There is synergy from government in terms of soft policies, importation of panels and battery waivers, subsidising the process of tax and other infrastructures needed to support the technology, On the private point of view, the individual promoters are readily, obeying the underline guidelines for promotion of the technology''. (Interviewee 'K').*

> *''There is a massive understanding and discussion flow between the federal government agencies; the ministry of power, energy commission, NERC and rural electrification to reach the rural communities through private participation in electricity access for all''. (Interviewee 'J').*

Majority the interviewees pointed out that the EPSRA 2005 was the birth for integration of private and public sector through PPP initiatives where government sales, ownership under the PPA to the private sector to engage in the energy mix. Government parastatals and agencies responsible for solar energy actualisation are held accountable to proffer implementing strategies to support solar energy initiatives promotion in all parts of the country.

An interviewee applauds the synergy and the opportunity given to private sector nationally and internationally. There are evident proposed mega solar farm projects in Katsina,

Kaduna, Abuja, Bauchi, Niger state and many other upcoming projects across the country. Other noticeable projects, in progress include the proposal to power all the federal Universities with standalone solar PV. It is also expected that hospitals, healthcare, public laboratories, schools, and government institution will benefit from solar energy initiatives. There are a number of licensed private companies with the right to operate, install, promote, and market solar energy in Nigeria and the companies are willing to commit towards the achievement of vision 20 20 and 20 30 (Oseni, 2012). The integration of public private partnership (PPP) converged a lot of activities in the mini -grids based. As a result, a forum was formed where both public and private stakeholder meets regularly to discuss issues bothering the industry and suggest mitigation strategies.

6.3 Lack of Access to Electricity and Energy Demand

92% (24 of the 25) interviewees argued that the Nigerian power sector is associated with challenges and the reforms has not mitigated the challenges over the years. It is perceived that the Nigerian electricity has not performed to its maximum capacity in the history of its existence. Emodi and Yusuf (2015) argued that the Nigerian population has not had access to electricity up to 50% capacity, 65% of those living in the rural communities are not connected to the national grid, while those in urban cities relies on 70% of their electricity power sources from diesel generators. One of the interviewees noted:

> *‘‘There is no electricity, not achieved 25% of electricity demand, 75% of rural communities are not connected to the national grid, the connected households have not achieved 15% access to a constant supply of electricity. Solar can be decentralised, produced near where it's consumed, independent electricity with no further bills, or Cost and*

convenient for the government in terms of deployment of infrastructure for grid lines''. (Interviewee 'L').

From the statement above, it is noted that one factor driving Nigeria to the need for solar energy implementation is the access to electricity is limited, hence there is a need to diversify to other options, potentially, energy mix. Sambo (2012) argued that Nigerian economic development will continue to suffer a backlash if the power sector continues to operate on conventional basis without renewable energy options. The interviewees lamented that majority of the Nigerian population has no access to electricity and the rural communities are not well connected to the grids. As a result, industries are folding, and socio-economic growth is negatively affected. For this reason, the need for solar energy to increase access to electricity cannot be over emphasised.

6.4 Electric Power Sector Reform Act (EPSRA) 2005

92% (23 of the 25) of the interviewees noted that the EPSRA of 2005 was a wakeup call for the Nigerian power sector, unbundling the apex PHCN and investing into the energy mix. The objective of the Electric Power Sector Reform Act (EPSRA) 2005 is to diversify into the energy mix, and built more mini grids for rural electrification. Solar energy, being the source with more potential in the country is receiving acceptance due to availability of sunshine and the commitment of the government to achieve electricity access. Interviewee T, I and O noted that:

''The EPSRA is the first call for the energy mix and the government is fully committed to the partnership of the private sector and financing bodies locally and internationally''. (Interviewee 'T').

''The establishment of Electric Power Sector Reform Act (EPSRA, 2005) was aimed to provide formation of companies to take over the full functions, operation, liabilities, assets and staff of the National Electric Power Authority (NEPA) and Power Holding Company of Nigeria (PHCN) in order to develop a competitive private public partnership for the energy market in Nigeria, of course we have seen the progress this Act is taking Nigerian power sector to''. (Interviewee 'I').

''The Act is a community development opportunity based, because it initiation has given the Rural Electrification Agency (REA) to diversify options for electrification to rural communities where deployment of national grid was sort difficult due to security and distances. Standalone solar PV cannot be deployed by contractors and train technicians in same local communities.'' (Interviewee 'O').

Both literature and the interviewees agreed that the power sector reform Act has been a major driving factor for solar energy because, the Act has broken the chain for the power sector monopoly.

6.5 Stakeholder's Commitments to Electricity Access

88% (22 of the 25) interviewees argued that stakeholder commitment towards electricity access is a driving factor for solar energy implementation. Although, the government has focused on the extension of national grid in the past, the public private partnership for energy mix has unveiled the need for alternative off-grid solutions (mini-grids and stand-

alone systems) to support the diversification of electrification solution in Nigeria. The interviewees argued that:

> *''The sensitisation commitment by the ministry of power and the rural electrification agency has yielded a massive awareness, resulting to private and public sector coming together with the same goal to achieve electrification solution especially the rural communities that has limited access to grid connections''. (Interviewee 'K').*

> *''There is a commitment by the stakeholders to half halt the abuse of electricity infrastructure, producing electricity nearly where it can be consumed and boycotting the expensive cabling network and deforestation just to access the communities''. (Interviewee 'H').*

> *''Communities now have schedules meeting with members of the distribution companies and local renewable energy promoters to discuss, challenges, tariff, security and access in various cities. This is a positive achievement to scale the solar energy market''. (Interviewee 'N').*

From the assertion above, 88% (22 of the 25) noted that, stakeholder engagement in the realisation of stable, clean and sustainable electricity through energy mix has played a vital role in fuelling the need for solar energy implementation in Nigeria.

6.6 Solar Irradiation Potential

88% (22 of the 25) interviewees argued that, potential solar irradiation is one of the leading factors that fuelled the need for solar energy initiative in Nigeria. Most of the interviewees

note that Nigeria and other African countries are located in the solar belt with high irradiation density to be able to have an average 9-hour sunshine a day. Therefore, the potential sunshine irradiation in the country, especially in the northern part, is a driver for solar energy implementation. This is affirmed by the solar energy stakeholder's interviewees:

> *''Massive sun irradiation we have in Nigeria, especially in the up-north zone, power sector reform, which called for the unbundling of the power sector and diversifying to renewable energy, the 3rd driver is ensuring we walk along with other nations towards achieving sustainable development goals (goal 7), the present government is committed to ensuring all Nigerians get electricity both rural and urban cities''. (Interviewee 'A').*

> *''Nigeria can generate, distribute and sustain its entire electricity for household and industry demand from solar energy, just by using 1% of its land area of the 923,768 km2 (356,669 sq. mi) considering the potential sunlight throughout the year''. (Interviewee 'F').*

> *''We as a country, have no excuse of whatsoever not to have electricity if countries in Europe such as Denmark, Spain, Germany, and the United Kingdom invests huge in solar energy as the weather is 80% cloudy, windy and raining mostly is winter. Nigeria has sunshine throughout the year, even during the rainy season and Harmattan season''. (Interviewee 'B').*

The assertion from the interviewee 'A' relate to unanimous literatures that Nigeria is strategically located on the sun belt with high sunshine density and therefore can withstand a potential solar energy option (Mohammed *et al*., 2013). In support of the literature, interviewee 'F', argued that Nigeria only need 1% of its land for solar farm to power the entire country with solar energy initiatives. The interviewees also argued that Nigeria should take a challenge to address the power outage through solar energy considering the potential it possessed. Thus, countries in Europe with little sunshine have taken a positive challenge for green energy, especially Denmark, Spain, Germany, and the United Kingdom. Therefore, sunshine irradiation in Nigeria is an indicator that there is an opportunity for solar energy stakeholders to power Nigeria through solar PV. As such, the opportunity is a driver for solar energy implementation in the country.

6.7 Institutional Policy for Energy Mix

After the power sector reform Act of 2005, objectives are being put in place, strategies are designed and roadmap for achieving the objectives was established. Among the institutional policy to support solar energy implementation is that the private sector can obtain licenses to build and promote solar energy to an approved private individual or partnership capacity. The federal ministry of Power in partnership with energy commission and rural electrification is working interwoven with the private sector to actualise the vision 2020 and 2030 to 15% and 25% solar energy access.

> *''The institutions, agencies and departments are working towards attaining the renewable energy objectives, energy laws for public private partnership, renewable energy for industrial development, interim measures for renewable energy prices and cost sharing policies would help shape the initiative to penetrate the market''. (Interviewee 'E').*

''The federal ministry of power, in collaboration with a standard organization of Nigeria, the Nigeria Customs Service (NCS), the Nigerian Electricity Regulatory Commission (NERC) and Energy Commission of Nigeria (ECN) has agreed to an import duty waiver for solar energy equipment to support the production and promotion of solar energy in the country''. (Interviewee 'C').

80% (20 of the 25) interviewees noted that institutional policy can either be a driver or a barrier and, on this occasion, the later hold true as the policy of the EPSRA have positively impacted the need for solar energy implementation in Nigeria. The interviewees noted that the collaboration of the MDAs towards solar energy implementation is an overwhelming indication that, the stakeholders of the solar energy promotion are working towards solar energy implementation. In addition, the MDA's feed-in-tariff is an indicator of a good institutional policy to support solar energy promoters in the country. Even though, literature has argued that the Nigerian power sector faces a series of challenges because the industry lacks proper institutional policy to support the electricity access (Sambo, 2012; Ogunmodimu and Okoroigwe, 2019). It is evident that institutional policy plays a vital role towards achieving any laid objectives. A good example is the power sector reform Act of 2005 which allows the private sector to invest in the solar energy promotion and development in Nigeria.

6.8 Favourable Environment and Land Access

The Nigerian government has designed strategies to support solar energy promoters, and one of which is the access to land where solar farms can be situated without hassle. In

addition, the government has intervened by working closely with MDAs to relax building regulations and make provision for solar rooftop access in recent years. Favourable environment for solar energy implementation includes waiver of taxes and duties for solar energy and accessories importations from all routes to the country as noted by the interviewees:

> *''The federal ministry of environment is working with the departments of lands and survey together development control to develop a user-friendly partnership for land and buildings intended for solar installation in all the state capitals and environs''. (Interviewee 'R1').*

> *''The federal government is liaising with ministries, agencies and department (MDAs) together with community leaders to encourage young people to participate in solar energy development by providing training and small-scale financing to enable a start-up process for the technology''. (Interviewee 'H').*

72% (18 of the 25) interviewees argued that, the Nigerian government has provided an enabling environment for solar energy promoters and end-users. The ministry of environment is ready to provide free lands for solar farm projects after the approval for participation is evaluated by the necessary agencies. The agencies responsible for regulating laws on electricity supply and building plans are encouraged to make necessary adjustment to enable solar energy promoter's participation. The assertions from the interviewees can be related to literature argued in Ohunakin *et al*., (2014) Fashina, (2018).

6.9 Market Competitiveness

The solar energy initiative is a new technology which is on the growing stage in Nigeria and Africa at large. The promotion and penetration of solar energy market are competitive with the conventional electricity system that is more popular to the regions. The acceptance of solar energy initiative in the market depends on the reliability as perceived from experienced end users and promotion strategies (Ohunakin *et al*., 2014). Thus, the interviewees expressed the following assertions:

> *''The market mechanism was missing because the promoters for solar and renewable lack support from either the government or the agencies responsible for promoting the energy in the country. Funding opportunities have been a breakthrough from the central bank of Nigeria and international funding agencies, such as USAID and the World Bank institutes''. (Interviewee 'O').*

The interviewees noted that the conventional electricity has dominated the energy market for a long period of time. Thus, solar energy has a promising competitive advantage to be accepted in both cities and rural communities in Nigeria. The solar energy market is growing in Africa, the initiative has greater potentials over other renewables market in Nigeria. Both literature and field data show that, there is a possibility for the solar energy market to take over the major share of electricity access in Nigeria especially the rural communities with limited grid connections.

6.10 Commitment to Achieve the SDG's Goal 7

Akinyele et al., (2015) highlighted that the Nigerian government is committed to achieving the Sustainable Development Goals as a member of the KYOTO protocol. An indicator of

the commitment is the Nigerian home groom sustainable strategy Nigerian Economic Empowerment and Development Strategy (NEEDs). The interviewees highlighted:

> *''The Nigerian government, KOYTO protocol and the SDGs are committed to achieving the mandate assigned at the national assembly in New York, Rio de Janeiro and Paris agreement of the United Nations Framework Convention on Climate Chane (UNFCCC) to ensure there is a stable and sustainable electricity in Nigeria''. (Interviewee 'T').*

60% (15 of the 25) interviewees agreed that the Nigerian government is committed to achieving the SDGs 7: '*Ensure access to affordable, reliable, sustainable and modern energy for all'* which is aimed at realising universal access to affordable and reliable energy by the year 2030. It is evident from the literature point of view and the assertion from the interviewees that the Nigerian government has made efforts to comply with the agreement made at the united nation general assembly on sustainable development goals. This commitment is one factor driving the stakeholders for solar energy towards implementation.

6.11 Economic Impact and Rural Development

The solar energy initiative implementation would be improving energy security and access. Aliyu *et al*., (2015) argued that energy access has impact on socio-economic development, especially in Nigerian rural communities where grid connection is limited. The interviewees highlighted the following assertions:

> *''Solar energy can bring huge development in villages, towns and most communities in Nigeria when they have access to electricity for small-scale activities. Those activities can help youth and women to develop*

skills for acquisition, which will be generating revenue for the actors and the government as a whole''. (Interviewee 'O').

''Unless quick action is taken to address the electricity challenges in rural communities across the country, the youths and unemployed will continue to contribute nothing to the society because electricity is the key to socio-economic development in any nation''. (Interviewee 'C').

60% (15 of the 25) interviewees asserted that solar energy deployment could bring huge development in rural communities for small-scale businesses. Implementation of solar energy could also create job opportunity and reduce the unemployment rate in both urban and rural communities in the country. Solar energy implementation would bring socio-economic development, reduce energy poverty, tackle climate change, and improve efficiency.

6.12 Job Opportunities and Employment Generation

When a solar energy initiative is implemented, the impact would improve economic development and reduce poverty. Because there would be an opportunity for skills development, technology transfer and other investment opportunities. Abdullahi *et al*., 2017b) argued that lack of electricity in Nigeria has contributed towards unemployment rate and its expected that solar energy development in the country is an energy option that will drive a variety of social skill acquisitions. The interviewees noted the following:

''In most of the communities around us, especially the rural dwellers, young people are indirectly disengaged from activities; they wander

around communities, especially during holidays, doing nothing, some become nuisance in the community''. (Interviewee 'R').

''The difference between Nigeria and the developed world is that youth apprentices, skill acquisitions and community development services are ignored by the leadership in local government areas in Nigeria. And therefore, such abandoned economic activity in the community results to community's bad influence and increase in community violence and disturbances''. (Interviewee 'P').

56% (14 of the 25) interviewees argued that solar energy implementation in Nigeria would increase opportunities for job creation through community development skills and small-scale business. This opportunity therefore drives the need for solar energy implementation in the country.

6.13 Energy Saving and Efficiency

Oikonomou *et al*., (2009) states that energy efficiency refers to technical ratio between the quantity of energy obtained and consumed whilst the energy saving refers the end-use energy saving addressing the reduction of final energy consumption. The energy saving and efficiency addresses the economic utilisation of energy, eliminating energy waste whilst achieving maximum benefit. Literature argued that Nigeria is currently consuming 0.2% of total world energy consumption, which the efficiency and saving compared to other developing countries is not met. The interviewees in this research highlighted the following observations:

''Nigeria as a country can achieve energy saving potential, a lot of energy is wasted because most people use electricity for free and do not know what value it has in the society unfortunately. But once you pay for the solar PV equipment, you will understand that your electricity generation worth saving effectively used and store excess generated for further use or sell to neighbour''. (Interviewee 'E').

''Reducing energy usage, especially lighting during the day, means reducing energy cost and as a result, the household can potentially result to financial cost saving while the other hand saving the environment for greenhouse gas emissions''. (Interviewee 'T').

52% (13 of the 25) interviewees noted that once solar energy is installed, the cost for the installation is spread over a long period of time, the economic benefit is ribbed, and the energy availability is continuously sustained. Therefore, energy saving, and efficiency are pillars for sustainable energy policy of any nation which Nigeria is not an exception.

6.14 Feed-In Tariffs

The National Energy Policy (NEP) was aimed at achieving optimal utilisation of energy resources and the reform policy was complimented by the Renewable Energy Master Plan (REMP) in 2016. The policy aim is to achieve 10% renewable energy contribution to the EPSRA proposed energy mix by 2015 and the investment in solar energy through Feed-in Tariff (FiT) structure (Adaramola, and Paul, 2017). For Nigeria to compete with other African countries such as South Africa, Morocco, Egypt, Kenya, and Algeria in solar energy development, the FiT strategy is a key instrument for encouraging private sector

participation. The benefits of FiT are shown in the following quote obtained from two interviewees:

> *''Feed-In Tariff is not currently in use in Nigeria, but the scheme is proposed under the objectives of EPSRA 2005, we hope when more people are committed to solar energy projects in Nigeria, one day individuals can generate electricity and sell it to make money''. (Interviewee 'M').*

> *''Feed-In Tariff is used in the UK, Germany, Denmark, USA, China and many developed and developing countries. We are working hard towards to vision 2020 and vision 2030 where 15% and 30% of the electricity we generate in Nigeria is expected to be from solar and other renewable''. (Interviewee 'K').*

The statements above clearly suggest that some government strategies such as the FiT are among the key factors driving the power sector towards solar energy implementation. The FiT is a money and environment saver because it enables the promoter to buy less electricity from the supplier whilst the promoter makes more money from the energy they produce (Adaramola, and Paul, 2017). It is therefore payment and incentive received by energy users from electricity generated by another user in excess, otherwise known as an energy cashback scheme for clean energy promotion.

6.2 Summary

The chapter highlighted factors that drive the need for solar energy implementation in Nigeria based on primary data collected from interviewees participated in the research. It is

evident that diversification of energy mix, especially solar energy, has driven the objective of the Electric Power Sector Reform Act 2005. The reform has broken the chain of power monopoly and has created opportunities for private energy investors to partner with the government under the PPP to increase energy access and cope the energy poverty. 80% of the interviewees argued that, before the EPSRA reform, the policies for energy, lack focus especially the long-term planning, thinking green, and opportunities for the private sector was limited. It was also noted that the government and other stakeholder commitment to achieve the reform's objectives drives the need for solar energy initiatives in the country. Other factors that are responsible for driving the Nigeria to energy mix include the availability for solar irradiation potentials that can be harnessed and be used to complement the conventional electricity that has been unstable in the country. The research noted that institutional policy plays a vital role for solar energy initiative promotion and development. The policies allowed the promoters and stakeholders to access the land and the environment where the initiative is to be situated. It is also evident that the solar energy market is growing at a steady rate and the opportunity is driving the implementation process. The promotion of solar energy initiative in Nigeria is an indicator of commitment by stakeholders to achieving the goal seven of the SDGs. The study reveals that, solar energy initiative creates an impact for socio-economic development for investors, youth empowerment, and community development. Saving energy and energy efficiency is one factor also driving the solar energy initiative. The Feed-In Tariff policy is another strategy that drives the stakeholders towards solar energy initiative implementation.

Overall, the following inferences and the implication could be documented to reflect the outcome from the literature and field work findings:

- The research result suggests that strategies for energy mix diversification stands out to be the most outstanding factor fuelling the need for solar energy initiatives. Long before now, the government has tried to diversify the power sector in the country, but the proposal has not been successful due to inconsistency and changes in government policies. In the year 2000, Nigerian power sector stakeholders proposed a reform to overhaul the power holding company of Nigeria due to consistent power failure and decaying of the company's infrastructure. The proposal was debated in the judiciary and approved where the process began 2003 and implemented in 2005. The realisation potentially will achieve the following benefits:

a) Political Independence: Nigeria as a state has long time relied electricity source from hydro and thermal. Spreading the supply from other energy options such as solar could reduce the burden of load overhead and to break the monopoly which have existed for over 100 years.

b) Energy Growth: Energy diversification is a key to socio-economic development. Drawing energy from multiple sources and independence suppliers, insulates the challenge for over reliance from a single supplier and the risk of uncertainties.

c) Environmental protection: A successful development of renewable energy resources such as solar power diminishes the treat of energy scarcity and improve the confidence of electricity independence suppliers.

d) However, there is a need to create a reasonable energy policy framework that can attract investment by rewarding Entrepreneurship and innovation and constraining inefficiencies waste.

e) There is a need to partner with the private sector to identify and develop alternative energy options to enhance electricity access throughout the country.

Overall, section 6.1 has addressed the first part of the 2nd research objective of the study, which is: *To investigate the key drivers, key barriers, key benefits of implementing solar energy in Nigeria.* Consequently, section Table 6.1 have answered the research question to the research participants which is: *What are the key drivers that have fuelled the need for solar energy technology initiative's implementation in Nigeria?''.* Although, the drivers fuelled the scaling up solar energy in Nigeria, a huge effort is needed to hasten the implementation of solar energy and other renewable energy projects in the country (Ohunakin *et al*., 2014). To be able to meet the electricity demand in Nigeria, there is a need to design specific policies for solar energy attributes with clear binding targets to be adopted for a percentage of energy portfolio and framework. There is a need to streamline the governance of existing solar energy policies to explore more innovative and emerging transparency capable of delivering solar energy initiative. The next chapter discusses barriers that challenged the implementation of solar energy initiatives despite the abundance of the full potential of the energy in the country. The chapter will also discuss the potential key benefits and beneficiaries of the initiatives when it is appropriately implemented in the country.

CHAPTER SEVEN

Key Barriers and Mitigation, Benefits and Beneficiaries for Solar Energy Initiatives in Nigeria

7.0 Introduction

This Chapter discusses the key barriers for implementing solar energy initiatives in Nigeria. Also, it discusses the key benefits and the beneficiaries of the initiatives when it is implemented in Nigeria. The outcome of this research is based on the discernment of the 25 participated interviewees who are high profile experts with experience and turnaround knowledge in solar energy initiatives in the country. In chapter three, six key barriers against solar energy implementation were identified from the literature review covering Nigeria and lessons from other countries. In the literature, the researcher also identified benefits of solar energy in Nigeria, especially amidst the power outages.

During the face-to-face interviews, the interviewees were asked questions one of which was: *What are the key barriers that hinder the implementation of solar energy initiatives in Nigeria?* The question sought to clarify and elicit inferences between the interviewees' responses and the outcome of the literature reviews and the new barriers that have not been identified in the literature. The section addressed the research question and achieved the second objective of the research which was: *To investigate the key drivers, key barriers, key benefits of implementing solar energy in Nigeria*. Table 7.1 represents the barriers that hinder the implementation of solar energy initiative in Nigeria, and these are discussed in detail between sections 7.1 and 7.1.10. The chapter also discusses the perceived benefits for implementing solar energy in Nigeria, especially with the growing negative impact of

greenhouse gasses in section 7.2 to 7.2.6. Finally, section 7.3 to 7.3.4, discuss the key beneficiaries for solar energy initiatives when it is implemented.

7.1 Key Barriers for Solar Energy implementation in Nigeria

Table 7.1 listed the key solar energy barriers with the percentage of interviewees assertion for each of the barriers identified:

Table 7.1 Key Barriers for Solar Energy Initiatives in Nigeria (N=25)

S/N	Key Barriers	No. of interviewee cited (N=25)
1.	Lack of Technical capacity	25 (100%)
2.	Socio-cultural Issues	23 (92%)
3.	Financial Barriers	22 (88%)
4.	Poor Policies and Institutional incapacity	20 (80%)
5.	Legal Implications	18 (72%)
6.	Promotion and Market Barriers	17 (68%)
7.	Lack of Awareness barriers	15 (60%)
8.	Economic Barriers	14 (56%)
9.	Lack of Research and Development Barriers	13 (52%)
10.	Weather and Climate Conditions	11 (44%)

7.1.1 Lack of Technical Capacity

100% (25 of the 25) interviewees noted that technical barriers affect the process of solar energy implementation in Nigeria. It is evident that solar energy initiatives are slowly gaining acceptance through promotion by the stakeholders in the power sector. However, there is also evidence that there is a lack of skilled personnel to meet a code of standard procure, to install and maintain solar PV in Nigeria. Inadequate experience and lack of know-how about the initiative could result to risk of low turn-out of customers accepting the initiatives and could result to risk in the investment. In addition, this barrier can lead to technology locked-up and the interviewees asserted that:

‘‘Technical expertise and training are lacking in the society. Promotion and sensitisation of the public are poor and misunderstood. The technology cannot be fully accepted by end users because they are not well informed of the benefits they enjoyed’’. (Interviewee ‘C’).

‘‘The technology is new to more than 80% of the customers, poor plans and coordination, too many gaps and loopholes, poor demand for the technology due to lack of awareness, cost of the technology, financing the technology, economic benefits and scales in rural communities is a challenge, technical capacity’’. (Interviewee ‘D’).

The affirmative view of the interviewees reveals that the promoters of solar energy initiatives in Nigeria lack the adequate technical know-how to the application and development of solar energy in the country. Regrettably, the issues of weak indigenous technology in Nigeria put a very strong limit to the potential opportunity for local manufactured power equipment and accessories in the country. As a result, Nigeria relies heavily on imported solar energy equipment which are expensive, especially to the rural community’s users who are mostly low-income earners (Mohammed *et al*., 2020). The technology workability needs to be understood by both promoters and end-users in order fully reap potential of the initiatives. This view is supported by Ohunakin *et al*., (2014), unless standard for good solar panels is set, the country will continue to suffer potentially low-quality solar panels and battery supply to the promoters. It is therefore apparent that solar energy promoters will need to create training and development scheme for solar energy for the promoters and end-users.

7.1.2 Socio-cultural Issues

92% (23 of the 25) interviewees noted that Nigeria is a country with more than 350 ethnic groups with different perception virtually in everything. Culture and ethnicity are popular, respected norms and values in Nigeria, and they have a massive impact of implementing solar energy initiative. Furthermore, religious belief and faiths might stand against the installation of solar panels in homes and designated locations approved by authorities. All these social barriers negatively affect the communities from generating socio-economic benefits of the initiatives, as asserted by these interviewees.

> *''Siting and transmission, market, unequal playing field and misconception, traditions, insecurity and more are hindering the promoters of solar energy in Nigeria to succeed''. (Interviewee 'A').*

> *''Perception of the technology has floated the market because some marketers imported substandard panels and batteries which failed to meet the efficiency and life span. The information goes around, and many people can believe it is all the same and therefore wouldn't want to buy and install the technology either for business or household services''. (Interviewee 'E').*

From the interviewee's point of view, the way people perceived the initiative can significantly affect its promotion and implementation. The religious issues and cultural challenges have negative impact in the deployment of solar energy projects in Nigeria. Sambo (2002) argued that in the past, the power holding company of Nigeria suffered a setback to connect many communities to national grid due to religion and culture

challenges. He added that the entire Mambilla plateau is not connected to the national grid, thus, solar energy initiative is potentially the opportunity to connect the region with solar mini-grids connections.

7.1.3 Financial Barriers

Solar energy is free from sunlight, but the procurement and installation of the equipment require financial commitment. The initial cost, otherwise known as upfront payment, is capital intensive that low-income earners in Nigeria cannot afford, especially the rural dwellers. In the Nigerian context, most of the solar PV promoters are private business enterprises who finances their business from private sources. There is, therefore, lack of access to financing; capital, credit, support of import duty and subsidies, and high risk for investment due to security challenges, as argued below by interviewees:

> *''In 2013, 2014, the battery cost about N52, 000/200/h, using 24 volts, in 2013 through 2014, solar panel prices were high, but the battery was cheap and in 2016 to 2017, the prices for solar panel reduced and the prices for battery became high. This fluctuation of prices is as a result exchange rate is a challenge to for the importers of solar panels and batteries''. (Interviewee 'J').*

> *''Economics and earnings status, especially low-income are obstacle to the technology. The initial start-up is high and very few people can afford to buy and install it even for part uses in homes. Most of the rural communities across Nigeria are not connected to the grid and therefore, solar energy technology can play a vital role in those areas''. (Interviewee 'K).*

Although, installation of solar energy panels and batteries does not require sophisticated infrastructural and expensive equipment on small scale solar, the financial status of an individual household earnings determines the financial capacity for a home solar energy power plant. Mohammed *et al*., (2020) added that, since Nigeria lacks the sufficient technology to manufacture solar panels and battery locally, the country relies on foreign importation from other industrialised nations at higher cost. As a result, Nigerian is at risk of sourcing the solar energy equipment out of the exorbitant cost, hence limiting the investment opportunity especially for large scale solar energy investment.

7.1.4 Poor Policies and Institutional Incapacities

80% (20 of the 25) of the interviewees noted that weak policies, procedures, regulations legislations and enactment in favour of solar and other renewable energy options is one major constraint for the progress of solar energy development in Nigeria. Even though, policies are proposed, the implementation process is challenged with issues linked to lack of adequate follow up, lack of evaluation and corruption within the MDAs as argued by the interviewees below:

> *''The institutional laws and regulations can be a big obstacle to young entrepreneurs. Until the government policies are driving the economy the solar energy is yet to get the full potential for the implementation". (Interviewee 'L').*

> *''Institutional barriers such as capacity building and proper framework for solar energy (NASENI), framework for financing and promotion of solar, there is no policy framework for tax relief for solar panels*

importers, expertise in the sense of knowing how much capacity can be loaded in the technology''. (Interviewee 'B').

From the above contentions, it is apparent that the strategies, procedures, and policies towards solar energy promotion are weak and inadequate (Ozoegwu *et al*., 2017). Mohammed *et al*., (2020) argued that solar energy development in Nigeria is slow because of poor policy declaration, immature regulatory framework, and lack of proper approaches for solar energy implementation.

Therefore, the Nigerian government need to formulate soft policies towards renewable energy to help the public private partnership to accelerate solar energy deployment especially in the rural communities.

7.1.5 Legal Implications

In Nigeria and most countries around the world, the environmental laws are proposed and enacted by the government. These laws need to be updated to suit the environmental habitants (human, animals and ecological) and their way of life. Private sector participating in the solar energy promotion is challenged by legal barriers. Despite progress by the EPSRA 2005 and what has been achieved up to date. There is no proper national renewable energy portfolio standard to mirror the reform Act measures adopted. It is important to note that crafting law for solar energy and enacting the law is fundamentally interdependent. The legislation to achieve the solar energy implementation is weak to achieve the inherent targets of the vision 2020 and 2030. An interviewee related the environmental law to the following:

''Monopoly of electricity, lack of legal framework for the solar energy process of navigation in rural areas for implementation, poor strategies for the inclusiveness of the private sector participation in the industry is delaying the deployment and development of the technology in the country. Unless laws are adjusted to give solar energy promoters the opportunity to design, build and install solar energy, Nigeria will continue to experience a power shortage''. (Interviewee 'G').

72% (18 of the 25) of the interviewees noted that there is a weak and unaccommodating environment for solar energy due to, inadequate laws, insufficient policies and procedures for procurement, development, and deployment of solar energy in the country. Ozeugwu (2017) argued that Nigeria can generate the entire electricity the country needs from solar by using only 1% of its land. This means that Nigeria has the potential for solar energy implementation, but the opportunity to harness the potentials are limited due to unsupportive legal framework for solar energy projects.

7.1.6 Promotion and Market Barriers

It is evident that there is no reliable energy option model in Nigeria, as such promoters for solar energy initiatives lack the turnaround strategy for implementation. The Nigerian solar market is currently suffering from imbalanced market competition with the fossil-fuel electricity due to the high cost of solar equipment. Solar-based initiatives in Nigeria is slowly growing and becoming uneconomical especially the rural communities where access to grids is limited and the solar energy became the best option as asserted by an interviewee:

''The market for solar energy product and equipment, such as solar panels, power inverters, exclusively battery power and AC generators are

yet to be accepted in many parts of Nigeria. As a result, many micro companies floated the market with substandard and cheaper version of the product, resulting in the technology rejection in many areas across the country''. (Interviewee 'R').

68% (17 of the 25) of the interviewees argued that the Nigerian solar energy market is relatively weak due to high cost of solar panels, battery, and accessories for installation. Ohunakin *et al*., (2014); Mohammed *et al*., (2020) argued that Nigerian government need to create an enabling environment for the solar energy promotion by regulating the prices of solar energy product and cost for deployment. In addition, the government and solar energy investors need to speed it energy strategies to be able to achieve the EPSRA objectives and the Sustainable Development Goals (SDGs).

7.1.7 Lack of Awareness

60% (15 of the 25) of the interviewees noted that the solar energy implementation process is challenged by lack of awareness to the technology and its benefits. It is evident that most of the solar energy proposed projects in Nigeria are targeted for communities where grid connection is limited. This barrier is related to people's mindsets, principles, behaviour, and perception to solar energy. While other issues are associated with illiteracy, human personal centric views and poor sensitisation about solar energy benefits as perceived by the interviewees:

''The technology is new to more than 80% of the customers, poor plans and coordination, too many gaps and loopholes, poor demand for the technology due to awareness, cost of the technology, financing the

technology, economic benefits and scales in rural communities is a challenge, technical capacity''. (Interviewee 'K').

The interviewee argued that solar energy market and acceptability is challenged by lack of awareness of the product design, usability and benefit that can be attracted when it is implemented. The barrier is peculiar with rural communities where this initiative is mostly needed for lighting and household usage. Although, the Nigerian government through the Rural the MDAs have created a medium for solar energy and other renewable energy sensitisation under the department for promotion and outreach, more effort is needed to achieve the vision 2020 (Abdullahi *et al*., 2015). It is evident from the interviewees and the literature reviews that Nigerians have a low level of awareness of solar energy product, technology, cost, financing sources, benefits, and potential opportunities. It is hard to achieve the solar energy implementation goals with low level of social acceptance. The solar energy promoters need to increase awareness campaign for solar energy product in order to drive the interest, desire and social acceptance of the initiative especially in the rural areas.

7.1.8 Economic Barriers

Solar energy projects are capital intensive due to their initial cost that require a long time to pay-back. The Nigerian economy has been affected by the global financial crisis, which crippled most of the sectors of the economy resulting in lower GDP output. More so, solar energy as a product lacks true costing and valuation, skewed and perverse incentives, lack of disclosures to any risk or effect to the promoters and the end-user. The barrier directly affects local communities due to low activities that results from low-income earning as

predominantly residents of the rural areas are farmers and herders. The interviewees asserted the following observations:

> *''Economics' earnings are one obstacle to the technology. The initial start-up is high and very few people can afford to buy and install solar panels. You can relate the rural communities where businesses are slow and income earning is low to take care of basic needs''. (Interviewee 'I').*

> *''Convincing the consumer on the reliability and sustainability of the product is a war between marketers and the consumers, issues of inadequate data for rural electrification and a survey of the cost and benefit analysis''. (Interviewee 'K').*

56% (14 of the 25) of the interviewees argued that cost comparison and competitiveness of the solar PV with conventional electricity are among the significant barriers for the adoption and implementation of the initiative in Nigeria. Ohunakin, *et al*., (2014) had argued that solar PV integration involves high upfront cost payment and the financial system in the country is unwilling to support the investment. It is evident that households earning determines the amount of solar PV investment in any community as such, the stakeholders need to increase solar energy market through local investment in small-scale businesses. Although, the government has allowed investors to develop and deploy between 100 kW mini grid and less than 1MW large scale mini grid, the economic status of the promoters need to be supported financially.

7.1.9 Lack of Research and Development

52% (13 of the 25) interviewees argued that Nigerian solar energy development lacks adequate research and development. Despite having five energy research centres in the country, solar energy initiatives are yet to be adequately integrated into academic curriculum to explore the skills and knowledge about solar energy development. In addition, there is an illiteracy rate in the northern part of the country where solar energy potential and opportunity is viable as noted by an interviewee:

> *''Northern part of Nigeria is full of potential for solar energy, but the region lacks full capacity for research and development about renewable energies in the country''. (Interviewee 'T').*

The interviewee argued that there are energy training centres in the country contrary to the perception that solar energy and other renewable do not have training centres in Nigeria. According to the ECN (2019) there are energy training centres collaborated with tertiary institutions in the research of solar energy, renewable energy, energy efficiency and conservation, hydropower, and petroleum resources in Enugu, Sokoto, Lagos, Ilorin, and Bauchi, respectively. In addition to the five training centres, there is a Power Training Institute of Nigeria (NAPTIN) in Abuja the capital city. (ECN, 2017). Both literature reviews and field data show that there is inadequate research and development around solar energy and renewables. The government and the private investors should therefore develop national energy research programs to monitor, evaluate and tract the affairs of the energy research centres to ascertain the progress.

7.1.10 Climate and Weather Condition

44% (11 of the 25) interviewees noted that, in the northern part of Nigeria, some places are extremely hot especially North-East and North-West. The efficiency and effectiveness of solar panels and batteries is negatively affected in areas with temperature more than 25*, as the efficiency of the panels declines between 10% and 25% as explained by an interviewee:

> *''Most of the solar streetlights in Abuja, Lagos and many other cities in Nigeria died off less than six months of installation, because the batteries were exposed to very hot weather condition''. (Interviewee 'P').*

From the assertion of the interviewee and reviewed literature, it shows that, solar panels and battery cannot function effectively and efficiently when they are exposed to certain temperatures. Aliyu *et al*., (2015) added that solar panel efficiency is likely to be affected, especially in the northern part of Nigeria where temperature rises to 45 degrees. Other adverse weather condition that can negatively affect the solar energy efficiency and lifespan include heat, dust, and high-speed wind.

7.2 Interpretive Structural Modelling (ISM) approach

Interpretive structural modelling (ISM) approach can be used to prioritise the barrier for solar energy implementation. The primary data collection and content analysis have yielded ten (10) barriers whereas, the ISM of the barriers tends to throw some light on the behavioural characteristics of the barriers. The ISM hierarchical structure of the barriers provides a platform to further analyse the interaction among the barriers and develop a roadmap to mitigate them in order of significance.

ISM was therefore employed to further analyse the interrelation of the key barriers to solar energy implementation in Nigeria. This was to ascertain the ranking, relationship, and the discrepancy between the barriers in the literature and the interviews. Table 7.2 shows coding for SSIM matrix for the key barriers which is followed by steps for building reachability, partitioning, and building the ISM diagraph.

Table 7.2 Coding for SSIM matrix for key barriers for solar energy implementation in Nigeria

Coding	Barriers
BI	Lack of Technical capacity
B2	Socio-cultural Issues
B3	Financial Barriers
B4	Poor Policies and Institutional incapacity
B5	Legal Implications
B6	Promotion and Market Barriers
B7	Lack of Awareness barriers
B8	Economic Barriers
B9	Lack of Research and Development Barriers
B10	Weather and Climate Conditions

After finalising the ten barriers from the semi-structured interviews, expert's opinion were obtained to ascertain the interrelationship between the barriers for solar energy implementation.

Table 7.3 Structural Self-interaction Matrix

	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
B1		V	X	X	O	V	V	O	X	O
B2			O	A	O	V	X	O	O	O
B3				A	A	X	A	A	V	A
B4					V	V	V	A	V	O
B5						V	V	O	V	A
B6							X	A	A	O
B7								V	A	O
B8									X	O
B9										V
B10										

Table 7.3 shows the contextual interrelationship among the barriers input into the Structural Self-Interaction Matrix (SSIM) where the interrelationship between barriers *i* and *j* were represented by *V A X O*.

Table 7.4 SSIM Reachability Matrix

1	**B1**	**B2**	**B3**	**B4**	**B5**	**B6**	**B7**	**B8**	**B9**	**B10**
B1	1	1	1	1	0	1	1	0	1	0
B2	0	1	0	0	0	1	1	0	0	0
B3	1	0	1	0	0	1	0	0	1	0
B4	1	1	1	1	1	1	1	0	1	0
B5	0	0	1	0	1	1	1	0	1	0
B6	0	0	1	0	0	1	1	0	0	0
B7	0	1	1	0	0	1	1	1	0	0
B8	0	0	1	1	0	1	0	1	1	0
B9	1	0	0	0	0	1	1	1	1	1
B10	0	0	1	0	1	0	0	0	0	1

Table 7.4 shows that the symbols of VAXO are being substituted by 1 and 0 in order to transfer the developed SSIM into binary matrix for further calculation and analysis.

Table 7.5 Reachability Matrix with Transitivity

	B1	**B2**	**B3**	**B4**	**B5**	**B6**	**B7**	**B8**	**B9**	**B10**
B1	1	1	1	1	1*	1	1	1*	1	1*
B2	0	1	1*	0	0	1	1	1*	0	0
B3	1	1*	1	1*	1*	1	1*	1*	1	1*
B4	1	1	1	1	1	1	1	1*	1	1*
B5	1*	1*	1	0	1	1	1	1*	1	0
B6	1*	1*	1	0	0	1	1	1*	1*	0
B7	1*	1	1	1*	0	1	1	1	1*	0
B8	1*	1*	1	1	1*	1	1*	1	1	1*
B9	1	1*	1*	1*	1*	1	1	1	1	1
B10	0	0	1*	0	1	0	0	0	0	1

As shown in table 7.5 above the final reachability matrix applied to identify the reachability and antecedent set of barriers and also for a level of partitions. Afterwards, the barriers for which the reachability set, and the intersection occupies the top level of hierarchy indicating

the likelihood of the barrier be affected. Once the barrier at the top level is identified, it will be removed from the reachability sets of subsequent other barriers.

Table 7.6 Level Partitioning (I)

Barriers	Reachability sets	Dependence set	Intersection	Level
B1	1,2,3,4,5,6,7,8,9,10	1,3,4,5,6,7,8,9	1,3,4,5,6,7,8,9	
B2	2,3,6,7,8	1,2,3,4,5,6,7,8,9	2,3,6,7,8	I
B3	1,2,3,4,5,6,7,8,9,10	1,2,3,4,5,6,7,8,9,10	1,2,3,4,5,6,7,8,9,10	I
B4	1,2,3,4,5,6,7,8,9,10	1,3,4,8,9	1,3,4,8,9	
B5	1,2,3,5,6,7,8,9	1,3,4,5,8,9,10	1,3,5,8,9	
B6	1,2,3,6,7,8,9	1,2,3,4,5,6,7,8,9	1,2,3,6,7,8,9	
B7	1,2,3,4,6,7,8,9	1,2,3,4,5,6,7,8,9	1,2,3,4,6,7,8,9	
B8	1,2,3,4,5,6,7,8,9,10	1,2,3,4,5,6,7,8,9	1,2,3,4,5,6,7,8,9	
B9	1,2,3,4,5,6,7,8,9,10	1,3,4,5,6,7,8,9	1,3,4,5,6,7,8,9	
B10	3,5,10	1,3,4,8,9,10	3,10	

Table 7.7 Level Partitioning (II)

Barriers	Reachability set	Dependence set	Intersection	Level
B1	1 ,4,5,6,7,8,9,10	1, ,4,5,6,7,8,9	1,4,5,6,7,8,9	
B4	1, ,4,5,6,7,8,9,10	1, ,4,8,9	1, ,4,8,9	
B5	1, ,5,6,7,8,9	1, ,4,5,8,9,10	1,,5,8,9	
B6	1, ,6,7,8,9	1, ,4,5,6,7,8,9	1,,6,7,8,9	II
B7	1,,4,6,7,8,9	1,,4,5,6,7,8,9	1,,4,6,7,8,9	II
B8	1,,4,5,6,7,8,9,10	1,,4,5,6,7,8,9	1,,4,5,6,7,8,9	
B9	1,,4,5,6,7,8,9,10	1,4,5,6,7,8,9	1,4,5,6,7,8,9	
B10	,5,10	1,,4,8,9,10	,10	

Table 7.8 Level Partitioning (III)

Barriers	Reachability sets	Dependence set	Intersection	Level
B1	1 ,4,5, ,8,9,10	1, ,4,5, ,8,9	1,4,5, ,8,9	
B4	1, ,4,5, ,8,9,10	1, ,4,8,9	1, ,4,8,9	
B5	1, ,5, ,8,9	1, ,4,5,8,9,10	1,,5,8,9	III
B8	1,,4,5, ,8,9,10	1,,4,5, ,8,9	1,,4,5, ,8,9	
B9	1,,4,5, ,8,9,10	1,4,5, ,8,9	1,4,5, ,8,9	
B10	,5,10	1,,4,8,9,10	,10	

Table 7.9 Level Partitioning (IV)

Barriers	Reachability set	Dependence set	Intersection	Level
B1	1 ,4,, ,8,9,10	1, ,4,, ,8,9	1,4,, ,8,9	
B4	1, ,4, ,8,9,10	1, ,4,8,9	1, ,4,8,9	
B8	1,,4,, ,8,9,10	1,,4,, ,8,9	1,,4, ,8,9	
B9	1,,4,, ,8,9,10	1,4, ,8,9	1,4,, ,8,9	
B10	,10	1,,4,8,9,10	,10	IV

Table 7.10 Level Partitioning (V)

Barriers	Reachability setss	Dependence set	Intersection	Level
B1	1 ,4,, ,8,9,	1, ,4,, ,8,9	1,4,, ,8,9	V
B4	1, ,4, ,8,9,	1, ,4,8,9	1, ,4,8,9	V
B8	1,,4,, ,8,9,	1,,4,, ,8,9	1,,4, ,8,9	V
B9	1,,4,, ,8,9,	1,4, ,8,9	1,4,, ,8,9	V

Table 7.11 Final Reachability Matrix

	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	Driving power
B1	1	1	1	1	1*	1	1	1*	1	1*	10
B2	0	1	1*	0	0	1	1	1*	0	0	5
B3	1	1*	1	1*	1*	1	1*	1*	1	1*	10
B4	1	1	1	1	1	1	1	1*	1	1*	10
B5	1*	1*	1	0	1	1	1	1*	1	0	8
B6	1*	1*	1	0	0	1	1	1*	1*	0	7
B7	1*	1	1	1*	0	1	1	1	1*	0	8
B8	1*	1*	1	1	1*	1	1*	1	1	1*	10
B9	1	1*	1*	1*	1*	1	1	1	1	1	10
B10	0	0	1*	0	1	0	0	0	0	1	3
Dependence power	8	9	10	6	7	9	9	9	8	6	

Table 7.11 shows the indirect influence relationship between the barriers in considering the transitivity where driving powers and dependence powers are identified. The next figure is the ISM model that shows the level and ranking of the barriers that hinders the adoption and implementation of solar energy initiatives in Nigeria.

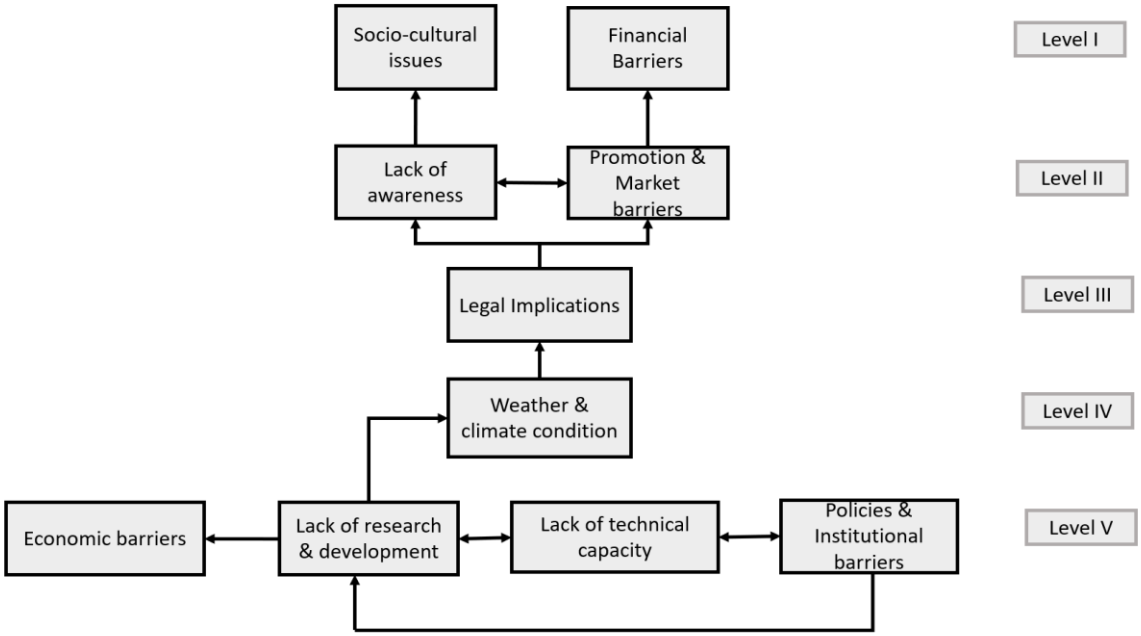

Figure 7.1. ISM model of barriers for solar energy implementation in Nigeria

Based on the result of the level of partitions, the ten barriers were positioned in the diagraph to present the chain of influence of the barriers.

As illustrated in Figure 7.1, the ISM hierarchy model included ten barriers-'Socio-cultural barriers', 'financial barriers', ' lack or awareness', 'promotion and market barriers', 'legal barriers', 'weather and climate condition', 'economic barriers', 'lack of research and development', 'technical barriers' and lack of policies'. At the top of the ISM hierarchy (level I and II), which are socio-cultural, financial, lack of awareness and lack of promotion and market barriers became more significant to the hinderance of solar energy implementation. Therefore, high priority measures to identify the root cause of the barriers and propose strategies for their mitigation is apparently inevitable. There are two barriers, these are: Legal barriers and weather and climate condition barriers which fall in the middle level of the ISM diagraph (level III and IV) which are influenced by the lower - level barriers

(level v) and in turn, impact on other barriers, i.e., the upper -level barriers (level I and II). Although, they are not on the top level, the solar energy stakeholders need to devote consistent attention to these barriers as their instability can affect other barriers. At the bottom of the ISM hierarchy model, the barriers namely; economic barriers, lack of research and development, technical barriers and lack of policies appears to be insignificant in terms of impact on solar energy implementation. Sindhu, *et.al* (2016) arguably identified financial and technical as they key barriers to solar energy implementation, whilst financial and lack of awareness as key barriers as asserted by Wyllie, *et. al* (2018). In the content analysis in table 7.1, socio-cultural barrier was 2nd in a ranking by the interviewee at 92% whilst the financial barrier was 3rd in the ranking by the interviewee at 88% respectively. On the contrary, technical barrier appeared to be the most important barrier, according to the interviews in the content analysis, whereas the technical barrier falls within the bottom level (level v). The next paragraph discusses strategies for mitigation of solar energy barriers in Nigeria.

7.3 Strategies for Mitigating Solar Energy Barrier in Nigeria

Having investigated the barriers that are obstructing the smooth implementation of solar energy initiative in the country, it is apparent to proffer sound, strategic mitigation option. The mitigation options will drive the solar energy industry towards achieving sustainable electricity, Nigerian vision 2020 (NV2020), and the sustainable development goal seven with the vision 2030 (affordable and clean energy).

Table 7.12 Key Strategies for Mitigation of Solar Energy Barriers (N=25)

S/N	Key Strategies	No. of interviewee cited (N=25)
1.	Awareness Campaign on Solar and other Renewables	25 (100%)
2.	Sustainability Initiatives	23 (92%)
3.	Rural Mini Grids Development	22 (88%)
4.	Standalone Solar Based Home Solutions	20 (80%)
5.	IPPs for Federal Universities and Teaching Hospitals	19 (76%)
6.	Power Sector Recovery Plan	18 (72%)
7.	Power Sector Stakeholder Engagement	16 (64%)
8.	Information and Transparency, Access	15 (60%)

7.3.1 Awareness Campaign on Solar Energy and Other Renewables

It has been shown in section 7.1.7 that there is a lack of awareness for solar energy development in Nigeria as (15 of the 25) of the interviewee suggested that a solar energy implementation need an awareness campaign to disseminate and inform the potential end-users about the benefits of the initiatives. The interviewees disclosed that the government through the MDAs have a department for a solar energy outreach platform for campaigning through television, radio and social media as stated below:

> *''We have what is called power consumer assembly, a forum where we meet with stakeholders and consumers and we do promote solar to let them know that they are options for electricity through solar rather than the conventional fossil fuel option''. (Interviewee 'G')*

> *''Rural Electrification Agency (REA) We are an agency responsible for rural electrification and we received directives from the minister of*

power, and we are also responsible for advocacy, trying to enlighten people about the promotion of renewable energy. As part of our CSR in the agency is enlightenment, sensitisation about the renewable energy advocacy''. (Interviewee 'S').

''Disco is doing an awareness campaign in print media, electronic media campaign, social media, radio stations television houses. Discos pay 6 months in advance for a radio advert to reach rural communities. We also tell them the importance of paying a tariff to raise money for alternative energy''. (Interviewee 'N').

The research interviewees confirmed that the solar energy promotion is low, and this is due to lack of awareness campaign to reach the potential consumers, especially the rural communities. Abdullahi et al., (2017a), argued that one of the barriers for scaling up solar energy promotion in Nigeria is lack of awareness. Although the government and its MDAs initiated the power consumer assembly and advertisement on media, the campaign progress need to be monitored to ensure the advancement of the outreach campaign.

7.3.2 Sustainability Initiatives

In recent years, the Nigerian government has established agencies under the power sector, which are saddled with responsibility to initiate strategies for renewable energy and sustainability initiatives. The initiatives are evaluated by the power regulator and monitor by the ministry of power under the office of the Vice-president to achieve 10% of the solar plan by 2020, 20% by 2030 and 30-40% by 204 as expatiated by the interviewees:

''We already have the clean energy initiatives plan in our ministry which is a renewable energy programme initiated to fulfil the obligation to the UN Framework Convention on Climate Change (UNFCCC)''. (Interviewee 'K').

''Nigerian renewable energy and energy efficiency policy NREEEP are developed by the federal ministry of power and was approved in 2015 by the FEC, which proposed 20% of the power supplies in Nigeria by 2030 should be renewable. As such, 6830 MW should be from Solar''. (Interviewee 'E').

''The initiatives are to ensure that solar electricity reaches all the nooks and crannies. We have established the National centre for energy efficiency and conservation (NCEEC), the Nigerian Electricity liability management limited (NELMCO), Nigerian electricity market stabilisation facility (NEMSF), the Rural electrification agency (REA), Nigerian Bulk electricity trader (NBET) and many more''. (Interviewee 'P').

92% (23 of the 25) of the interviewees noted that there are several sustainable initiatives integrated into renewable energy policies to support the promotion of solar energy in the country. From the inferences, an interviewee pointed out that the Nigerian government already has policies for sustainability under the UN climate change convention. The statement is supported by another interviewee who further expatiated that Nigerian have a

home groom energy efficiency policy (NREEEP) with targets to achieve 6,830 MW of solar energy by 2030. In addition, interviewees shed light on more energy policies meant to promote solar energy sustainability. Ozoegwu, *et al*., (2017) emphasised that sustainability for solar energy is essential and therefore, stakeholders need to monitor the promotion and deployment to adhere with the regulators.

7.3.3 Rural Mini Grids Development

In this study, 88% (22 of the 25) of the interviewees asserted that one of the strategies mitigating solar energy barriers in Nigeria is to develop rural mini grids, popularly known as off grid electrification. As part of the government commitment, the Rural Electrification Agency (REA) was created under the power sector reform Act to prioritise electrification to rural communities. The rural communities have a limited grid -connection and the mini grid is an opportunity to tap the economic potential and to restore basic social amenities. The focus of these projects is solar -based mini grids which can be rollout to integrate with the distribution companies under the PPA's scheme. This is shown in the quote by an interviewee:

> *''The policy documents are produced to support the projects, the newly introduced mini grids in rural areas to support the socio-economic activities in rural communities where access to electricity is limited''. (Interviewee 'O').*

The above assertion revealed that there is an effort by the government to unify a road map for locating, planning, and operating decentralised rural mini-grid system for low-income earners in the country. Ugwoke et al., (2020) supported the assertion that solar hybrid mini-grid will play a vital rule in Nigerian rural communities to support farmers in irrigation and

other small-scale business. The rural communities produce 80% of the Nigerian food crops for local consumptions and export purposes and therefore need electrification to maintain the business path. Given the high share of rural population in Nigeria, application of solar mini-grid electrification to rural communities transcends mere electricity access and in-turn result to positive contribution to the GDP.

7.3.4 Standalone Solar Based Home Solutions

The standalone strategy is an uprising initiative for urban and rural communities in Nigeria. The rural communities will have provisions for solar home's systems (SHS), solar lanterns, solar charging points and many other products for other areas where mini grids are not potentially viable. Although, the stand-alone solution may also include an individual solar PV system that can provide sufficient power to cover the need of a household such as TV lighting, radio, fan, fridges and DCs and even for small commercial quantity.

> *''One way to mitigate the barriers is to train as much as possible on the technical aspect of solar and also the promotion so that the benefit of it is spelt out clearly to the users so that standalone electricity target can be achieved''. (Interviewee 'J').*

80% (20 of the 25) of the interviewees noted that, there is a need to train and re-train technicians and end-users for solar standalone solar- based to understand the workability and enable the utilisation of the systems for home and small-scale businesses. In so doing, the awareness for solar energy initiative is widely spread across the marketers and end-users.

7.3.5 IPPs for Federal Universities and Teaching Hospitals

Many educational institutions in Nigeria struggled to withstand the overhead cost of electricity, diesel generators which is operated as a back-up for power failure. As part of the power sector reform Act strategy for energy options, a plan has been put in place to power the 37 federal universities and 7 university teaching hospitals from off-grid systems. The IPPs initial plan allows Universities to operate a standalone mini-grid solar PVs between 1-10 MW to energise the university and teaching hospital facilities. According to the interviewees, the capacity is expected to be increased and extended to other government parastatals. One of the interviewees quoted that:

> *''We have an on-grid plant, but we realised that we don't have an off - grid plant, critical clusters; hospitals, Universities who need nearly 10 MW for their institutions''. (Interviewee 'I').*

In the assertion above, 76% (19 of the 25) of the interviewees noted that, there is a plan for solar off-grid electricity for all the federal universities and teaching hospital in the country. The projects are expected to be completed before the end of 2025 and state owned, and private institutions will be integrated to off-grid electrification through solar PVs IPPs for mini-grid electrification too. Emodi and Boo, (2015) added that, private universities could emulate the IPPs for the federal universities system to increase access and power the institution's infrastructure. The IPPs and teaching hospital project's progress need to be applauded considering about six Universities have already committed standalone powering infrastructure by 2016.

7.3.6 Power Sector Recovery Plan

Nigeria has experienced constant electricity failure for many years and the result is negatively affecting investment opportunities in the country. Businesses have been driven to rely on expensive, unsafe, and polluting diesel generators as the main power source. The option is expensive and unhealthy to the environment as it increases the greenhouse gases. It is evident that the power sector has had a narrow and unrealistic short term power plan which led to the privatisation in 2003. The new ownership of the power sector found it necessary to have a power recovery plan in 2017 to generate electricity from solar end other energy options off-grid solution. The interviewees expatiated that:

> *''As a solution, the federal government with its stakeholders came up with Federal Government Economic and Recovery Growth Plan for 2017-2020, where medium term structural reforms to diversify the Nigerian economy including restructuring and expanding power sector infrastructure as a priority. The strategy is a continuation of the 2016 roadmap for incremental, steady and uninterrupted power supply in Nigeria''. (Interviewee 'L').*

> *''As part of energy poverty mitigation plan, appointment of qualified Board members and qualified government representatives has been made who are saddled with responsibilities to oversee the distribution companies engaging in energy mix development as prioritised under the electricity recovery plan''. (Interviewee 'G').*

72% (18 of the 25) of the interviewees pointed out that, the power sector recovery is a priority set by the government to be achieved by 2020. To achieve the plan, more energy options are established, including standalone electricity and solar mini-grids projects across the country.

Bamisile et al., (2017) added that solar energy is expected to produce 1.26%, 6.92% and 15.27% of the electricity consumed by 2015, 2020 and 2030, respectively as part of the power recovery plan. If these targets of the recovery plan are met, the proportion of the population with access to electricity will increase drastically and this will have an economic impact in the country. The plan also encourages private sector participation under the public private partnership scheme in order to realise the objective of the power sector reform Act.

7.3.7 Power Sector Stakeholder Engagement

The power sector stakeholder engagement is a communication scheme developed to measure, monitor, and manage stakeholder relationship with the entire power sector. The engagement comprises of holding workshops, seminars, presentations, roundtable discussions, communication, and dissemination of deliverable strategies. The stakeholder engagement is comprised of key stakeholders of the power sector in the country as explained by an interviewee:

> *''We are part of the ministry of power and remain the government owned company, we help the ministry to deliver a comprehensive strategy for achieving electricity for all Nigerians especially the standalone strategy for rural communities''. (Interviewee 'A').*

64% (16 of the 25) of the interviewees noted that one of the ways in which solar barriers can be mitigated is by engaging the stakeholders at all levels in the development and supply of solar energy, especially the private sector. Stakeholder engagement would increase awareness of solar energy benefits across end users and increase appetite for market opportunities. It appears that the stakeholder engagement in the power sector will bring together the stakeholders to discuss issues around the power sector challenges and suggest strategies for improvement.

7.3.8 Information and Transparency, Access

It is evident that solar energy promotion, lack transparency in information sharing and as such, the awareness campaign is low across the industry. The communication between the stakeholder and the end-user is not well-structured to ease communication between solar energy promoters and consumers. One of the interviewees argued that:

> *''We have an on-grid plant, but we realised that we don't have an off - grid plant, critical clusters; hospitals, Universities who need nearly 10 MW for their institutions and this is a barrier for a solar power initiative which need to be addressed by unlocking pivotal information to the stakeholders and keep the loop informed''. (Interviewee 'N').*

60% (15 of the 25) of the interviewees noted that, information can play a vital role in the dissemination and promotion of solar energy initiative, which has been a barrier where the acceptance is inadequate, especially in the rural communities. The government needs to create an information hub where solar energy stakeholders can interact with the MDAs and the consumers.

7.4 Key Benefits for Solar Energy Initiative in Nigeria

Having investigated the barriers that are obstructing the smooth implementation of solar energy in the country, it's become apparent to further the investigate the benefits that can be derived from solar energy initiatives when it is implemented.

Table 7.10: Key Benefits for Solar Energy Initiatives in Nigeria (N=25)

S/N	Key Benefits	No. of interviewee cited (N=25)
1.	Economic and Financial Benefits	24 (96%)
2.	Environment Benefits	23 (92%)
3.	Socio-economic Benefits	21 (84%)
4.	Technical Reliability and Resilience	18 (72%)
5.	Low Maintenance Cost	16 (64%)
6.	Diverse Applications	15 (60%)

7.4.1 Economic and Financial Benefits of Solar

Solar energy is considered as one of the reliable, efficient, and effective sources of energy options with overwhelming benefits. Solar energy is derived naturally from the sun's rays and the initiatives can be installed on a home's roof and stand-alone system to give electricity for lighting, heating, cooking and other household utilities. Solar panels are expected to last between 30 and 40 years once they are properly installed to a required standard procedure to meet the expected long-term lifespan. One of the benefits of solar energy is the feed-In Tariff which provide great saving by generating revenue from selling the excess energy to either neighbours or back to the grids. Furthermore, the benefit of the solar energy initiative is that it has the capacity for eliminating electricity bills after the initial cost of the equipment installation cost. An interviewee quoted that:

''Can create jobs, the investor can make their money through the new policy. The public sector, it is the demand because we really need this

power to bridge the gap between demand and supply of electricity in the country''. (Interviewee 'B').

Almost 96% (24 of the 25) of the interviewee noted that solar energy deployment and implementation accrue huge financial and economic benefits. Solar energy is a driver for the socio-economic growth of any country because the energy is derived from sunlight with little infrastructure requirement. Ikiz, (2014) reiterated that considering the huge benefits of solar energy, many cities and states around the world have goals to become 100% clean by building homes with solar panels. From the assertion above, it shows that solar energy associated with huge economic and financial benefits as the initiates strives increase in income, improve business opportunities, create jobs, and contribute to industrial development.

7.4.2 Environmental Benefit for solar energy

The world depends largely on fossil fuels for daily energy needs, the impact of this energy on the environment cannot be over emphasised. The obligations to reduce the CO_2 gaseous emission to conform to the Kyoto protocol is the reason many countries drive the opportunity to harness their energy from solar and other renewable. Solar energy deployment serves as one of the environmental protection measures that can protect the world from the climate change impact. An interviewee stated that:

''Power is power, but solar energy provide energy that is cleaner, safer, environmentally friendly, the opportunities are endless, from utility scale, to small scale, medium scale mini grid usage, productivity on farms, the renewable energy especially solar can transform the country and that's why we are moving towards diversifying the means''. (Interviewee 'F').

92% (23 of the 25) of the interviewee asserted that, the implementation of solar energy can play a vital role in saving the environment from pollution and negative impact of greenhouse gases. Kalogirou, (2004) maintained that solar energy reduces air pollution, mitigate climate change, reduce household carbon footprint, and help us to save the planet. This shows that solar energy benefits to the environment is overwhelming, as a result, Nigerian energy stakeholders should invest in the industry to contribute towards the SDGs goal seven, eleven, thirteen and fifteen.

7.4.3 Socio-economic Benefits of Solar Energy

With many economies facing energy poverty around the world, economic policy makers increasingly see opportunities for balance trade, greater income, job creation and friendly environment. Solar energy value creation can be measured by both micro and macro-economic variables such as valued added for domestic product and welfare. Deployment of solar energy initiatives in rural communities increases the socio-economic activities in the areas and add value to the national output of the GDP. An interviewee stated that:

> *''Power is power, but solar energy provide energy that is cleaner, safer, environmentally friendly, the opportunities are endless, from utility scale, to small scale, medium scale mini grid usage, productivity on farms, the renewable energy especially solar can transform the country and that's why we are moving towards diversifying the means''. (Interviewee 'C').*

84% (21 of the 25) noted that solar energy implementation in Nigeria has potential for many businesses to grow and compete with the rest of the world in productivity. The statement is supported by Aliyu et al (2015) who argued that Nigeria needs to

harness the potential solar energy readily available as measures to mitigate the power outage in the country. With this contention, the solar energy benefits can be summed-up to lower utility bills, net energy metering (NEM), value increase, job creation and reduction of greenhouse gases.

7.4.4 Technologies Reliability and Resilience

Solar energy initiative is the energy option that does not require sophisticated infrastructure to be deployed, it requires only solar panels, batteries, space, and connecting. In addition, deployment of solar energy requires installation permits, inverter, hardware, wiring and interconnection which are the basic facilities that can provide an uninterrupted and unlimited electricity. Solar energy enhances reliability by mitigating grid disturbance to the environment, reduces energy lost in transmission and reduces cost per-unit-cost.

> *''Its free, little cost of operation except initial cost, zero maintenance cost, it can be controlled by conservation, control loads and switching, can be small scale generation for personal purpose uses''. (Interviewee 'L').*

72% (18 of the 25) of the interviewees noted that solar energy initiative is reliable and resilient as the technology is easy to install, easy to maintain and have the capacity for smart metering. Zhou *et al*., (2018) added that the reliability and resilience of solar energy initiative are overwhelming, especially the ease of independent connection for mini and micro-grids electrification compared to the conventional electricity.

7.4.5 Low Maintenance Cost

64% (16 of the 25) of the interviewees noted that, solar energy systems possess enormous benefits including low maintenance cost because the systems do not require regular

intermittent maintenance. According to the Global Adaptive Solar Collectors Market Outlook 2016-2021, solar energy promoters are more concern about the solar PV initial cost cells whilst the solar panel maintenance remains negligible. Solar panel manufacturers are expected to offer standard warranty for the systems between 20-25 years. However, solar energy inverters need to be replaced after every 10 years in order to maintain efficiency and effectiveness of solar panels. One of the interviewees emphasised that:

> *''Solar panels only need to be kept clean in areas where dust and debris affect the direct contact of the sunlight to the panels. This maintenance requires no financial implication because the owners of solar panels can clean them and make them work efficiently and effectively. An example of these areas is the Northwest and southwest, especially Yobe and Maiduguri that are considered part of the Sahel areas''. (Interviewee 'C').*

From the statement, 64% (16 of the 25) of the interviewees argued that solar panels do not require regular maintenance because they are built with the resilience to withstand long -term weather conditions.

7.4.6 Diverse Applications

During this investigation 60% (15 of the 25) of the interviewees noted that solar energy initiatives have diverse applications for various purposes. For instance, Onasanya (2017) argued that remote villages in Nigeria have limited access to electricity and solar energy option can be used to power schools' infrastructures, healthcare facilities as well as small-scale businesses. Solar energy can also be

used to power borehole water pumping system in rural communities with no access to pipe-borne water. The interviewee asserted that:

> *''We can use solar energy for small-scale industries, community vocational training centres such as sewing, crafting, mechanical and technological processing of materials and computer services. Without electricity the youths in our community are virtually discouraging in community development skills''. (Interviewee 'R').*

The statement by the interviewee shows that solar energy initiative plays an important role in community sustainable development. Solar energy deployment increases access to electricity as a result, socio-economic activities can be intensified. Other applications include integrating solar energy into building material for smart building such as transparent solar energy windows. The next section will discuss the potential beneficiaries for solar energy initiative when it is implemented.

7.5 Key Beneficiaries for Solar Energy Implementation in Nigeria

The presided section discusses the potential benefits of solar energy implementation in Nigeria. However, there is a need to further discuss the beneficiaries of the solar energy initiative when it is implemented. Although, the interviewees remarked that solar energy benefit is huge, and the implementation could benefit the promoters, government, and rural community dwellers. The interviewees argued that the following could be potential beneficiaries:

> *''The government can generate revenue through tax from promoters and relieve from the pressure from the high cost of gas prices and transportation. The private promoters make money from selling their*

product like panels and battery for installation while the technicians make money from installation and site surveys. The consumer benefit of enjoying the service with no further tariff and it is healthier for the environment''. (Interviewee 'AI').

''Those living in the rural areas like farmers and cattle herders who need the electricity for their small -scale businesses to grow. The entrepreneurs, and other power sector departments and agencies will also benefit from this promotion because they will realise revenues from it and the government too from taxes''. (Interviewee 'Q').

''Solar energy manufacturers, marketing companies and promoters of the technology and even the installers can benefit from the market, which is slow now, but have a potential to rise in the future''. (Interviewee 'D').

The interviews argued that the government can generate revenue from the solar energy promoters, the promoters on the other hand can generate financial benefits from selling their product while the end users benefit from the services. The interviews also asserted that the development of solar energy strategy can economically benefit rural communities where access to electricity is limited for a daily small-scale trader. About 80% of the interviews confirmed that solar energy manufacturers in Nigeria now benefit from tax free and levies as part of the EPSRA objective to mitigate energy poverty.

7.6 Summary

In summary, the world is faced with unprecedented global climate change that affect the environment where we lived, the economic growth and social activities. Unless, the challenges are tackled, with sustainable, renewable energies like solar, the challenges will continue to escalate. And the impact will negatively affect humans, animals and aquatic environment. Although, effort is made by the Nigerian MDAs to deploy, build and supply solar energy in various capacities, the process of implementation is challenged by plentiful barriers. The interviewees on this research, perceived the following barriers, most have hampered the speed of the solar energy deployment and implementation in Nigeria. 100% of the participants argued that, one of the biggest barriers to solar energy initiative in Nigeria is the lack of technical knowledge and technological know-how of the initiatives. Whereas 92% of the interviewee stipulate the concern barrier to be associated with cultures, religious and social behaviours towards the initiative. Other barriers that hinder the smooth process for solar energy implementation in Nigeria include the financial cost and implication, especially the initial cost, institutional policies, not favouring the promoters, laws surrounding the legal right to promote solar, poor market structure for the initiative, lack of awareness and sensitisation to the benefits for solar, economic scales for affordability of product, inadequate research and development and environmental survey for solar scale and impact from weather condition to the solar panels and storage. The ISM method countered the content analysis as the ranking of technical barriers moved to the lower level, whereas the socio-cultural and financial barriers on the first level shows that these two barriers are more significant to affect solar energy implementation in Nigeria.

Nevertheless, solar energy initiatives possess a lot of benefits which are categorised to economic benefits, environmental benefits, and socio-economic benefits. Other benefits

include the reliability resilience of the product itself, low maintenance cost for the solar panels and accessories and the power to diverse application for the systems. These benefits are perceived by the stakeholders, but not limited to other benefits that can be accrued from implementing solar energy in the country. The chapter also discussed the key beneficiaries of the initiative, where the participants noted that governments at all levels, rural communities where access to electricity is limited, promoters, entrepreneurs and manufacturers of solar panels and the MDAs could benefit from solar energy development across all tiers for socio-economic development activities.

From the literature review point of views, study, the most outstanding barriers for solar energy implementation is predominantly lack of technical knowhow about solar energy (Ohunakin *et al*., 2014; Abdullahi *et al*., 2017; Ozoegwu *et al*., 2017). The correspondence from the interviewees is on the same emphasis while the outcome from the ISM modelling contradicted the perception as socio-cultural and financial barriers top the list of the ten barriers identified. It is, therefore, apparent the stakeholders for the solar energy promotion take the following steps to move forward:

- Create workshops for training and development about solar; site surveying, potential risk and benefits, installation, positioning, weather and other factors that can affect the efficiency and the life span.

- Training on the technical aspect about voltage, volume, kilowatts, megawatts and the services which are suitable for the initiatives and those services that can lower the efficiency of the initiatives.

- Promoters need to create awareness for the end users about the storage of solar energy, duration of batteries, volumes, dangers, and the risk of overloading the voltage etc.

Ohunakin, et al. (2014) asserted that awareness of renewable energy sources is misunderstood not only in Nigeria but in the entire Sub-Sahara African countries. Nigeria with the largest population in Africa, where more than half of the population does not have access to electricity, making it apparent that Nigerians need to understand the potential benefits of harnessing electricity from solar. The rural area of Nigeria is mostly not connected to the grids and therefore can benefit from solar PVs installation. But the rural communities where these services are highly needed, have very little or no awareness of the benefits of the initiatives. The respondents also added the following reasons for the awareness challenges:

- End users are scared from the perception that the solar panels in the market are predominantly substandard and therefore might not function to full capacity to meet the demand for electricity for household utilities and small - scale businesses.

- Over the last 20 years, big projects on solar and other renewable energy projects have been proposed, awarded to various contractors, especially rural community lighting, sadly, the progress and the completion of many of the projects are untraceable.

- End users are not well-informed on the volume and load for which a solar energy panels can successfully carry and the amount of energy that can be stored at a particular time.

The solar energy industry has also suffered setback from financing from all sources, this is due to the perception of the market, past project factors and lack of tract records. Ozuegwu, et al. (2017) argued that abandoned power projects, lack of tract records and progress is a challenge ruining foreign investors in the Nigerian power sector. Other factors that played a vital role in the solar energy promotion is poor and complicated policies. Unless suitable and sustainable solar energy policies are proffered and implemented the entire system will continue to struggle.

It is with this purpose, the stakeholders for solar energy promotion in Nigeria need to take drastic measures as follows:

- Create workshops and training sessions for all energy options for both promoters and end users across the country, especially rural communities where these initiatives are highly needed.
- Increase the awareness campaign to cope the perception, for end users, promoters and investors and impose the right policies on both private and public sector participants.
- Government should increase funding options for promoters and end users, in order to encourage low-income earners to get involved in the solar energy market.
- Solar energy MDAs should integrate positive policies for solar energy promotion and development in order to boost the solar energy market in the country.

CHAPTER EIGHT

Framework the adoption of Solar Energy Governance

8.0 Introduction

In the pursuant to objective three of this research, this chapter presents the integrated research outcome. The chapter discusses the framework to facilitate the adoption of solar energy governance in the Nigerian power sector with consideration to findings from literature reviews and empirical data in the preceding chapters. The chapter commences with a discussion on the roots to power sector challenges, the factors that drive the country to the need for solar energy as alternative sources, the barriers that prevent the solar energy implementation process, the benefits that can be accrued on the successful implementation and the potential beneficiaries for the initiatives. The framework is based on theoretical approaches to provide better understanding and explanation of why implementation of solar energy initiatives is important arguably in (Nelsen, 2015). It is expected that the successful implementation of solar energy initiatives in Nigeria will boost the socio-economic well-being, create enabling environmental sustainability and drives rural community development.

8.1 Rationale for a Framework for the adoption of Solar Energy governance

Framework is a general theory and concept underpinning organised ideas where connections between identified components are integrated (Wiebe *et al.*, 2010). Ostrom (2011) argued that framework is an act of generating theory from a very important inquiry for the purpose of organised outcome. In this study, the framework draws a connection from the roots of power sector challenges to the drivers that fuelled the need to integrate solar energy to the energy mix. The framework also identified barriers and mitigation

strategies, the benefits for adopting and implementing solar energy and potential beneficiaries for the initiatives. To implement solar energy initiatives in the country, it is apparent to stress how stakeholders involved in the process from procurement of the material resources and sites to the installation and testing of the initiatives. Osinowo *et al*., (2015) argued that the power sector lacks coherent coordination among the stakeholders, thereby creating a loophole in monitoring the progress towards successful implementation of the initiatives. Interviewees D, in their assertion noted that one of the key factors hindering the successful implementation of solar energy initiative is the lack of an integrated framework and roadmap for the initiatives. They further lamented that, if the government and public sector failed to create a framework for solar energy and other renewable.

The power sector's stakeholders, therefore, need to have a framework for implementing solar where the driving factors can be identified, challenging barriers and their impact on economic development can be identified and the socio-economic benefits can be reaped through strategies and sustainable solutions. The emergences for solar energy implementation framework create inter-connectivity from the initial process phase, the factors that fuelled the need for implementation and the mitigation strategies for any barrier that challenged the success of the implementation process. In the early phase, the inability to propose a sustainable long-term policy was observed as weakness from the government infrastructure planning and therefore caused the power sector an overwhelming gradual collapse.

8.2 Towards Research Outcome

The research outcomes identified an expected scientific contribution from the in-depth research from the literature review and the empirical data. Also, the understanding of theoretical aspect and the result from a scientific analysis was integrated. The outcome is

interconnected in the framework after the following variables are carefully discussed and analysed in the research:

8.2.1 Power Sector Challenges

The study noted that the Nigerian power sector is affected by several challenges, which made the sustainability for power in the country almost impossible. The power generation, transmission and distribution did not make any significant progress for many years. Between 1995-2005, Nigeria generates the highest of 8000 MW of electricity, transmit and distribute so stations and sub-station only 3500 MW. In December 2017, the generation capacity hit 13,000 MW and the transmission to distribution reached its highest peak of 5, 156 MW. This capacity is expected to benefit only about 53 million Nigerians. It was gathered that the power sector is vested with enormous challenges, including the inability of the previous government to propose and implement long-term sustainable policies and to secure the infrastructure for the power from vandalism, cable theft and financial embezzlement. The challenges are discussed with references to chapter five, section 5.1.1 – 5.1.7.

8.2.2 Key Strategies and Reforms to Overcome the Challenges

Over the years, different reforms, approaches and strategies have been identified to address the challenges that face the country's power sector for a long period of time. Chapter five of the research establishes various strategies to mitigate the power sector challenges which includes the unbundling of the Power Holding Company of Nigeria (PHCN) to GenCo's, TCN and DisCo's. EPSRA was aimed to privatise the PHCN and establish opportunities for the energy mix as discussed in chapter two, section 2.2.2 – 2.2.6. The privatisation allows private companies to participate in the generation of electricity from solar energy, as

a result, they are hundreds of solar energy projects that are expected to generate a significant capacity of electricity by the year 2030. Although, they were strategies and reforms for the power sector, developed a strategic policy, framework and roadmap for affordable, sustainable and uninterrupted electricity is missing. The strategies and reforms are detailed in chapter five, section 5.2.1 – 5.2.5.

8.2.3 Key Drivers for Implementing Solar Energy Initiatives

The key drivers are the factors that fuelled the need for solar energy initiatives in the country. The drivers are key elements needed as inputs for the promoters and stakeholder to actualise the implementation process to achieving the sustainable solar energy development. The key drives are the leading factors affecting performance not only for the solar energy initiatives, but also for the promotion of other energy mix. The key drivers for solar energy initiatives in Nigeria are exhaustively discussed in chapter six, section 6.1 – 6.14.

8.2.4 Key Barriers for Solar Energy Implementation

The solar energy implementation is challenged by many barriers, as a result the entire process of implementation is inevitably slow and the hope for implementation is almost uncertain. The barriers are discussed from the empirical data in chapter seven, section 7.1 – 7.2. With content analysis and interpretive structural modelling (ISM).

8.2.5 Strategies for Mitigating Solar Energy Barriers

The following strategies are proposed to help tackle the identified barrier for solar energy implementation in Nigeria and other countries with similar challenges in Africa and across the globe. The successful achievement of the strategies will lead to achieving the Sustainable Development Goals (SDGs) seven (Affordable and clean energy) (Chirambo,

2018). The detailed strategies for the mitigation can be traced to chapter seven, section 7.3.1 – 7.3.8.

8.2.6 Key Benefit for Implemented Solar Energy

The following indicators are identified as benefits that can potentially be achieved when the solar energy initiative is successfully implemented in the country. The benefits are detailed in chapter seven, section 7.4.1 – 7.4.6.

8.2.7 Key Beneficiaries for Implemented Solar Energy

The following sectors are expected to benefit largely among other on successful implementation of solar energy in Nigeria. Detailed of the beneficiaries is featured in the empirical data analysis in chapter seven, section 7.5.

Inputs

The inputs are the antecedent elements that facilitate the implementation of solar energy initiatives (Mohammed and Hamilton, 2007). The power sector strategies and reforms are also driving factors that can be input to facilitate the process for solar energy implementation. The inputs of the framework include the power sector diversification in the energy mix, proposed liberated and enacted into law as Electric Power Sector Reform Act (EPSRA) whose objectives is to venture into the energy mix such as solar. Furthermore, the diversification called to the actualisation of the PPPs where the synergy between the public and private sector is strengthening the generation and distribution for solar energy sources. Perhaps, the EPSRA served as a clarion call to the power sector in the country, breaking the monopoly and power, given the private sector opportunity to participate in all phases to actualise energy sustainability in the country. Other factors that drive the framework to realisation include a commitment from both government and private sector on power,

availability of sun irradiation for potential solar energy generation, institutional policies for energy mix, favourable environment and access to potential solar energy initiatives project siting, solar energy market potentials, commitment to SDGs goal 7, small and medium scale business and job opportunities and guarantee for energy saving. The strategic mitigating factors also served as input drivers for the framework. The driving forces for solar energy implementation is an integrated element fuelled to actualise the realisation of solar energy initiatives and the sustainability of clean and affordable energy in the country.

Processes

The process is the intermediary and activity between input and output, which influence the input factors in order to realise an output (Mohammed and Hamilton, 2007). It is the second phase of the framework which comprises reforms, stages and sub-stages that comprise power sector challenges that has directly and indirectly affected socio-economic development. Identifying the key barriers that challenged the implementation of solar energy initiatives, the strategies for mitigating the barriers, the measurement and monitoring of the strategies, the key benefits that can be accrued after the successful implementation of the initiatives and the potential beneficiaries for the initiatives. Simply put, the process is a selection of appropriate and suitable tools and techniques to achieve the desired outcome of a research.

Output

The output refers to the accomplishment and the end result of the input and process which determine the success and failure (Mohammed and Hamilton, 2007). Upon, implementation of the outline solution strategies, the socio-economic benefits of solar energy initiatives are expected to be realised. The successful implementation will yield direct and indirect

benefits for the government and the MAs. Furthermore, the benefits of this initiative can easily be accrued and potentially help in the development in rural communities where access to energy is limited.

8.3 The Framework

Having, discussed the power sector challenges and strategic reforms, key drivers that fuelled the need for solar energy initiatives, key barriers that hinder the implementation of solar energy, the strategies for mitigating the barriers, the expected benefits after the implementation and potential beneficiaries for the initiatives. There is a need to conceptualise and integrate the factors into a framework for solar energy implementation. However, the implementation needs some elements known as input, which put in place to gear towards the achievement of desired results. The input is those factors that drive the need to process the objectives towards an overall output.

The process on the other hand, involve the identification of perceived power sector challenges that almost ruined the entire power sector for more than 123 years. Upon identifying the strategies and reforms in the power sector, solar energy appeared to have priority due to its potentials in the country. Even though, the implementation process is burdened with plentiful barriers. Key strategies for mitigating the barriers was proposed in order to harvest the potential benefits for the initiatives. Addressing the barriers has become seemingly important in order to achieve one of the objectives of the SDG's goal and the EPSRA objectives. In addition, the potential beneficiaries for the solar energy initiatives are also identified within the process to serve as feedback that will drive the solar energy promoters towards realisation of the solar energy and energy mix.

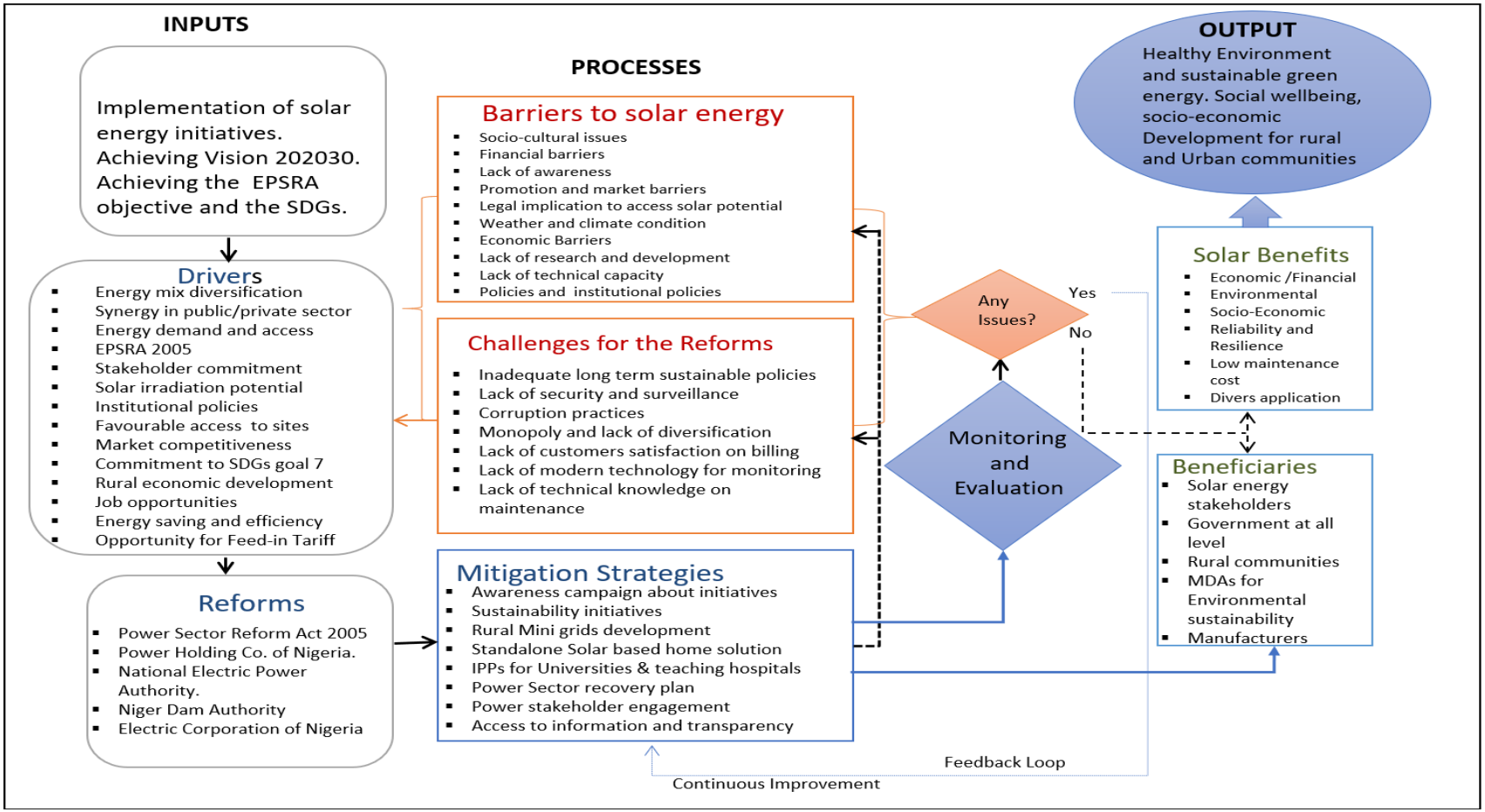

Figure 8.1 Framework to facilitate the adoption of solar energy governance in Nigeria.

8.4 Research Framework Evaluation

The preceding section presented an integrated research outcome in a form of summarised diagrammatical format to guide the stakeholders for solar energy, to utilise the strategies to implement the initiatives in order to provide a sustainable and uninterrupted electricity from solar. Although, the research findings cannot be 100% reliable, until the result is run in an evaluation process to establish validity and reliability. The evaluation process is part of the accomplishment of the research objective four which is developing and evaluating research framework.

8.4.1 Rationale for Framework Evaluation

The aim of the evaluating the research framework is to determine whether the research findings used for developing the framework are reliable and to determine the significance of the strategic recommendation for the framework. The framework for solar energy implementation was designed as a result of consolidation of all the research outcomes. From the, challenges of the power sector, drivers that fuelled the need for solar energy deployment, barriers for the implementation, key strategies for barrier mitigation, benefits, and beneficiaries for the initiatives and this is further discussed:

- To assess the reliability of the framework on the challenges of the power sector and the underpinning strategies and reforms therein to unravel the challenges.
- To assess and clarify the importance of solar energy drivers that fuelled the need to generate electricity through solar energy initiatives.
- To affirm from the participants' point of view on the key barriers to solar energy implementation and the proposed mitigation strategies.

- To confirm the importance of the benefits of solar energy initiatives when it is successfully implemented.
- To assess and clarify from the participants' point of view on the key beneficiaries identified in the research.

To achieve the evaluation process, the same stakeholders' ministries, Departments and Agencies (MDAs) are approached and used for the evaluation.

8.4.2 The Concept of Evaluation

Evaluation is a process of providing documentary evidence on any process, procedure or activity geared towards an expected result. It is the degree of providing assurance for a specific process leading to meeting a pre-determined quality of attributes. It, therefore, serves as the requirement to assess quality, assurance to originality and consistency in achieving a set objective in research (Rau and Williams, 2016). The validation is to ensure that each phase of the research choice of methodology is rigorously achieved and adhered to the standard acceptable for quality research. The evaluation, therefore, encompasses the process to establish validity of the research and to intensify the rationality of the research design adopted to achieve the overall quality in planning, executing and evaluating the research.

Evaluation is also considered to be the process of weighing the degree of accurate measures signify the true purports to be measured in an investigation result (Lucko and Rojas, 2010). The process of validation can broadly be categorised into internal and external validity as successfully practiced by many researchers (Keyur *et al*., 2014).

Internal evaluation is characterised by the concept of interconnection and is inattentive with the derivability of relations with the data (Li *et al*., 2018). On the other hand, external

evaluation is associated with a concept of induction and the emphases are on the generalisability of the research outcome (Hansen *et al*., 2019).

External evaluation is the process of establishing the extent of the generalisability of research findings irrespective of disparities around situations, persons involved, and the research design and method employed (Subramoniam *et al*., 2013). In other word, the external evaluation process is aimed to promote assurance of reliability in the research findings and it is also a process of translating findings to knowledge.

In this research, the external evaluation was achieved by allowing the solar energy stakeholders to share their perceived views on the solar energy implementation framework. The framework identified numerous drivers and reform strategies that fuelled the need for solar energy initiatives. As a process, the framework featured the identified power sector challenges that crippled the socio-economic development and the barriers that challenged the solar energy implementation process. Furthermore, the key benefits and beneficiaries that can be accrued after successful initiative implementation was identified.

Instrument for Framework Evaluation

The research adopted data from two main sources to validate the solar energy implementation framework.

- **Interviews:**

  The stakeholders for solar energy development and promotion in the country were interviewed. These include directors, executive directors, deputy directors, national energy promotion coordinators, managers, head of departments, a top official in the financial sector, and top officials for solar energy promotion. The data collected focuses on identification of power sector challenges, reforms and strategies to

moderate challenges, factors driving the need for solar energy initiatives, barriers that affect the implementation, mitigation strategies, benefits and beneficiaries for the initiatives. This also includes the views of the research participants on the accuracy of the proposed framework content.

- **Documentary Analysis**

  Documentary analysis was obtained from the review of literature, which focuses on data from achieving documents to capture the solar energy status in the country. Furthermore, focuses on the proposed and progress of solar energy projects, challenges and barriers facing the progress, synergy between the stakeholders in promoting solar energy initiatives, government policies for promoting solar and visions to achieve sustainable solar energy initiatives.

Internal Evaluation of the framework

Internal validity on the other hand, is the degree of validity on statements made, to who chooses what (X causes Y) aiming to rule out the reasonable contending hypothesis (Zbrozek et al., 2013). The internal Evaluation assesses the quality of the literature review and seek to outline the strength of the framework. Internal evaluation is achieved in two ways; agreement through academic evaluation accomplished through research, publications and findings from published research. The academic evaluation characterised the dissemination of findings of the research sourced from academic conferences, seminars, workshops, peer review journal papers, forums and symposium. The peer review publications and conference presentations give the researcher opportunity for the research to be questioned by independent peer reviewers and panel judges. The criticism creates a room for improvement after members in the academics scrutinise the research findings by critics, feedback, comments, and recommendations. Most parts of this

research have been featured in workshops, seminars, congresses, forums, conferences, and academic journal where the feedback strengthened the focus to achieving the research aim.

8.4.3 Background of Organisations and Participants Profiles

Four of the twenty organisations participated in the main research, were involved in the framework validation process. Out of the twenty organisations participated in the research, ten organisations were contacted to partake in the research strategic framework. The background of the organisations; position, organisations, and years of experience are presented (See Appendix F)

8.4.4 Discussion of the Validation feedback

A total of six individuals was drowned from four stakeholder organisations to study, assess and validate the research framework. The participants' discussions are categorised into four main themes: perceived usefulness of the framework, the adequacy and completeness of the framework, feasibility and reliability of the framework recommendations and the suggestions for the improvement of the framework.

Usefulness of the Framework

It was noted that all the six participants were of the view that the framework present a useful information for implementing solar energy initiatives. The six participants responding to the question on ‘whether or not the proposed framework for solar energy implementation possess is well-structured, well-informed and all-inclusive approach to achieving the research aim and research objective four. All the participants are positive and answered yes, the framework could serve as a revolution to power sector and basis for the solar power promoters. Director from organisation A; Initiatives for renewable and rural power access agreed that his organisation looks forward to adopting this framework, when he further made the following remark:

''I am actually impressed and motivated with the good work and the variables on this framework, I and my team will be waiting to have your permission to adopt the framework in our strategic roadmap for the implementation''.

The participant from organisation A whose key responsibility is to develop strategies and initiatives to achieve the objective of decentralised power through renewable energy for rural communities is astounded with the framework. The participant further suggested that the only way the power sector in the country and the stakeholders in solar energy can harmoniously find a solution is to identify the key barriers and the mitigations for solar energy development which are key aspects of the framework. The Assistant General Manager: Renewable Energy Regulations of Organisation B, on the other hand noted:

''The last part of the framework identified the key benefits, and the beneficiaries are very useful to the promoters because the percentage of people aware of the solar energy benefits are very small''.

Identifying the solar energy benefits plays a vital role not only for the framework development, but also for the end users whose strategies focus on socio-economic benefits for implementing solar energy initiatives. Other participants from organisations M and R mutually argued that the framework will help the stakeholders to match mitigations against barriers and use the recommendation as basis for solar energy implementation.

Adequacy and Completeness of the framework

The six participants from four organisations mutually viewed the framework as adequate. All the participants agreed that the drivers are adequately identified as factor responsible for the needs of solar energy in the country. The deputy director for solar energy research of organisation R, confided with the comments above that the framework is adequately useful. While organisation R added that:

> *''The framework identified key power sector challenges, including poor financing and corruption practices, this is being known and not properly disclosed in many research due to unavailability of data and disclosure issues. The framework traced the reforms and strategies, including the Power Sector Reform Act that triggered the need for an energy mix for the country and the EPSRA served as a key driver on the other hand''.*

The research revealed that the power sector was not making a significant progress over the last 109 years before the electric power sector reform act was enacted into law. The framework adequately featured the strategies to achieve one of the EPSRA objectives, sources power from alternative energy mix.

Feasibility and Recommendations of the Framework.

The degree of which the framework is conveniently done, is feasible and the recommendations upon the outcome is a true translation of the research objectives. The strategic manager for corporate strategies and projects for organisation M, reiterate that:

> *''I have carefully studied the framework, and I have come to conclude that, it does integrate many things, challenges, barriers, mitigations, benefits and*

beneficiaries. Where the successful monitoring will ease the achievement of the research aims''.

The assertion above indicates that the respondent, fully understood the framework and he have confidence that the implementation means a lot not only to the power sector, solar energy promoters but also to the end users. The researcher went further to ask the respondent on how he thinks the framework can be implemented. The respondents suggest that, the stakeholders need to use the research recommendation as a basis for the solar energy initiative planning, monitoring and implementation roadmap. On the other hand, the director of renewable energy and rural electrification access of organisation A asserted that:

''The framework is smartly designed; it unveiled the actual real situation on the power sector and the status of the solar energy development. I think the government should buy this idea and use the framework as a recovery plan against the failed promises we continued to receive''.

The responded of organisation A, agreed with the assertion that the solar energy promotion in the country is full of uncertainties and therefore, need the framework as a recovery plan and the recommendations are useful not only for the stakeholders but also a basis for further research within the renewable energy industry.

Feedback for the Improvement of the Framework

The views of the participants generally suggested that the framework has exclusively captured the important aspect of the solar energy implementation process. The director of renewable energy and rural electrification access express shock to the reason why corruption was not

placed as 100% cause for the power sector challenges and the biggest barrier for solar energy promotion. He further added the framework is adequate, but at the same time, stakeholders need to reveal the truth cause for the challenges and barrier even if they are associated with the corruption itself. He reiterates recent research hardly trace the corrupt practice as a challenge because most of the interviewees are sceptical to be referenced to the source. On the other hand, the assistant general manager for renewable energy regulations says:

> *''The framework is fantastically designed and has captured key characteristic needed to pull the solar energy towards achieving the 15% solar by 2020 and 40% by 2050. We are optimistic, research such as this will take us a long way to realise our goals for stable and sustainable electricity from solar''.*

The assertion from the DGM for renewable energy sought to point out that, the framework is an indication that an effort is made not only for the stakeholder industries but also in the field of research and development. It is apparent that the validation process proved that the framework developed for solar energy implementation in Nigeria will serve as a suitable roadmap for both private and public sector not only in Nigeria but also for other Sub-Sahara African countries with similar potentials. The overall feedback from all the participants for the frame is positive and the recommendation for the framework are adequately commendable. The participants mutually perceived the framework content is commendable to have identified challenges, barriers, drivers, benefits and beneficiaries for the solar energy initiatives. Henceforth, there were no changes done to the framework after the validation.

8.5 Summary

In summary, the chapter has discussed the framework development considered appropriate for solar energy implementation as a main contribution of the research. The framework rationale is specified as a simplified diagrammatic roadmap for solar energy initiatives. The chapter also presented the concept of the framework and the instrument for validation of the framework. The validation participant is presented accordingly in the framework reference. The chapter encompasses the validation feedback where the participants are all positive to the usefulness of the framework. The participants' feedback also shows that the framework adequately fits and complete for implementation. The participants are positive to the degree of feasibility and validity of the framework when the strategic recommendations put into good practice. The next and final chapter on this research concludes the findings of the research according to the aim and objectives that was earlier stipulated in chapter one.

CHAPTER NINE

Conclusion and Recommendations

9.0 Introduction

This chapter is to draw conclusions from the research findings on solar energy implementation in Nigeria and to suggest recommended to the solar energy stakeholders and future researchers. The chapter, therefore, discusses the aim and the objectives of the research. It also presents the key findings and recommendations.

9.1 Research Process

The aim of the research is to facilitate the governance for implementing solar energy in Nigeria, and achieve this aim, the following measurable objectives have been developed:

1. To explore the Nigerian power sector reforms, challenges, and renewable energy options with emphasis on solar energy and its status in Nigeria.
2. To investigate the key drivers, key barriers, key benefits of implementing solar energy in Nigeria.
3. To develop a framework to facilitate the governance of solar energy implementation in Nigeria.
4. To evaluate the developed framework with relevant solar energy stakeholders.

The underlisted objectives were achieved through a qualitative research approach, where data were collected from 25 professionals and stakeholders within the power sector and solar energy agencies in the country. The interviewees include executive directors, head of departments, directors, general managers, deputy directors and other professionals within the power sector. The interviews were audio recorded, saved, transcribed, coded, categorised, themed, and analysed using conventional content analysis and Interpretive Structural Modelling (ISM) were adopted for the key barriers for solar energy implementation.

9.2 Key Findings and Conclusions

The key findings of the research were achieved by addressing the proposed objectives of the research as follows:

> **Objective One:** *To explore the Nigerian power sector reforms, challenges, and renewable energy options with emphasis on solar energy and its status in Nigeria.*

The outcome of the literature and a field work study in this research reveals that electricity in Nigeria could not be sustained due to several challenges. These challenges are: Inadequate long-term sustainable policies, lack of securities and surveillance, corrupt practices, energy monopoly, lack of customer satisfaction with the billing system, lack of monitoring technologies and lack of technical knowledge. The findings revealed that Nigeria has been unable to generate a reasonable electricity to meet the demand of high growing population since 1896, due to poor policies and lack of prioritising the importance of electricity in the socio-economic development of the country. It was also gathered that a substantial amount of electricity is wasted on transit, theft and vandalisation of the power sector infrastructure due to lack of security, lack of monitoring surveillance and abandoned projects. While corruption practices contribute immensely to the lack of growth and development of the power sector. The MDAs are saddled with responsibility for the generation, transmission, and distribution of electricity from all sources to ensure energy access for all Nigerians. Sadly, millions of Dollars budgeted for electricity improvement and development projects are diverted and unaccounted, as a result, existing infrastructures became decayed and obsolete to perform to maximum capacity effectively and efficiently. Although, there has been an attempt for improvement strategies and reform to sustain the power sector severally, the strategies and reforms lack clear direction, and coherent to meet the fast-growing population's energy demand. However, the

enactment of EPSRA was a wake up and commendable reform that integrated the public private partnership and diversification of the Nigerian power sector into the energy mix.

It is concluded that, Nigerian government was unable to propose sustainable strategies and reforms that could achieve stable and sustainable electricity over a period of time. The power sector infrastructure appears to be semi-abandoned, as the electrical equipment is unmaintained, obsolete condition new projects abandoned. Therefore, it is apparent the entire power sector infrastructure be considered as public property, be secured and maintain for future development and improvement. Between 1896 and 2001, there has not been a significant evidence of maximum generation, transmission, and distribution of electricity to the end users due to corrupt practices within the power sector industry. For Nigeria to generate a sustainable, efficient electricity, a holistic and sustainable long-term polices on power generation need to be put in place. In so doing, energy option like solar energy sources will gain more attention from the national and international investors. Moreover, the Nigerian government need to tackle the corrupt practices and halt it promotion to the minimum level to allow developmental projects to take place.

Objective Two: *To investigate the key drivers, key barriers, key benefits of implementing solar energy in Nigeria.*

The research findings identified 14 key drivers which are diversification of energy, synergy in public, private partnership, energy demand, EPSRA Act, Stakeholders' commitment, solar energy potentials, institutional policy, favourable environment, market competitiveness, commitment to SDGs, solar impact on rural economic development, job creation, energy saving and Feed-In Tariff. Literature reviews and empirical data show that, diversification to energy mix has played a vital role for both public and private sector to participate in the

development of solar energy in the country. As a result, the synergy between public and private sector partnership for solar energy development is strengthened the findings also show that there is high demand of electricity access, which is limited, especially in the rural communities and this reason drives the need for solar energy implementation. The factors identified in section 3.6 and table 6.1 of this research are the driving forces thrilling the Nigeria power sector towards solar energy implementation. While the drivers are fuelling solar energy implementation, the process is challenged by barriers.

The study identified ten key barriers that challenged the implementation of solar energy initiatives in Nigeria. These barriers are lack of technical knowledge, socio-cultural issues, financial barriers, poor institutional policies, legal implications, promotion and market barriers, lack of awareness, economic barriers, lack of research and development and weather condition. Sociocultural barriers, financial barriers and lack of awareness stands out to be the factors that challenged solar energy implementation in Nigeria as demonstrated in figure 7.1. For solar energy deployment to succeed in the country, these barriers need to be addressed.

Part of the research objective two, is to identify key strategies to mitigate the barriers for solar energy implementation. The research findings proposed eight key strategies (see Table 7.2) that are believed can mitigate the underlying solar energy barriers in Nigeria. The strategies are: Awareness campaign, sustainable policy initiatives, rural mini grid development, standalone solar based for homes, IPPs integration for tertiary public institutions, power sector recovery sustainable plan, stakeholder engagement and access to information and transparency in the power sector. The most outstanding mitigation strategy for solar and other renewable energy barriers is the creation of sensitisation and awareness campaign about solar energy, its benefits to the end users and the environment. Also, stands out of the strategies is proffering sustainable policies for solar and other energy mix for a longer period of time. Rural mini grids

are also considered as one of the key options to mitigate the barriers because the rural communities play a vital role in the economic development.

The objective also tends to identify the key benefit of implementing solar energy initiatives in Nigeria. The research findings revealed six key benefits (see Table 7.3) for implementing solar energy initiatives in the country, which includes: economics and financial benefits, environmental benefits, socio-economic benefits, technical reliability, low maintenance cost and the availability of diverse applications. Although, the research emphasis on the benefits of solar energy is placed on the economic and financial benefits. It is expected that when solar energy projects are deployed and executed, especially in rural communities where access to electricity has become difficult, the communities engaged in development activities that generate incomes and increase the life standards of the dwellers.

Objective two also identified the key beneficiaries for solar energy initiatives when it is successfully implemented. These include solar energy stakeholders, government at all levels, rural communities, MDAs for environmental sustainability and manufacturers for solar energy.

Therefore, it is concluded in the research that energy diversification, PPP synergy and energy demand stands out as key drivers, among others. The inability to address socio-cultural issues, sourcing for solar energy financing and lack of awareness is hindering the implementation of solar energy initiatives in Nigeria. However, awareness and sensitisation on solar energy and other renewable energies could be an outstanding mitigating factor for solar energy barriers. Solar energy initiatives are associated with many benefits, economic and financial benefits are mostly considered outstanding, especially for rural community development, where access to energies are limited.

Objective Three: To develop a framework to facilitate the adoption of solar energy governance in Nigeria.

The research integrated data from literature review where challenges for the Nigerian power sector, reform strategies and privatisation. The research also identified drivers that fuelled the need for solar energy initiatives in Nigeria, barriers that challenged implementation and the strategies for mitigation. Furthermore, anticipated benefits for the solar energy implementation and beneficiaries for solar energy initiatives were also identified. These findings are literature based and therefore needed a holistic verification to a degree of evaluation and further data that could be a significant finding. Fieldwork research ethics and consideration was proposed and approved to collect data from the stakeholders across the power sector MDAs in Nigeria. A semi-structured interview was conducted from 25 top management staff within 20 organisation and the data was recorded, transcribed, coded, categorised and themed. The data were analysed using content analysis as presented in chapter 5, 6 and 7 and key barriers to solar energy in chapter 7 was further analysed with interpretive structural modelling (ISM) to ascertain the outstanding barriers. The outcome of the data analysis was integrated into a research framework.

The framework for solar energy implementation was developed. The framework provides important guidance for the integration of solar energy initiatives which, when implemented, will help in the socio-economic development that is fraught by the power outage in the country. The findings from the initial stage of the research literature review were integrated into the empirical data to stimulate the framework development and evaluation. The framework development consists of three (3) stages: inputs, process and outputs.

Objective Four: To evaluate the developed framework with relevant solar energy stakeholders.

The evaluation of the framework was done with six interviewees from four stakeholder organisations. The framework was evaluated based on four main themes: perceived usefulness, the adequacy and completeness, feasibility and reliability and suggestions for the improvement of the framework. There were no changes incorporated into the framework after the evaluation.

9.3 Research contribution to knowledge

This research has contributed to knowledge in the following ways:

- In the Nigerian power sector challenges in chapter two, section 2.3, the literature reviews identified corruption, fossil fuel gas domination and lack of maintenance culture as the key challenges facing the power sector. The empirical data collected and analysed in chapter five section 5.2, the research identified seven key power sector challenges (see Table 5.1) which are believed to have been the main cause to why the Nigerian power sector collapse and unable to generate and supply adequate electricity in the country. These challenges are considered as one of the research contributions to knowledge.
- In chapter three sections 3.6, the literature reviews identified nine key drives for solar energy implementation, while the empirical data collected and analysed in chapter six, table 6.1, fourteen key drivers for solar energy implementation in Nigeria was identified. The new drivers identified from empirical data serve as the research contribution to knowledge.

- Chapter three sections 3.7, the literature reviews identified six key barriers to scaling up solar energy initiatives. While the empirical data as presented in chapter 7, table 7.1 identified ten key barriers for solar energy development and implementation in Nigeria. In addition, the application of the Interpretive Structural Modelling (ISM) method has

changed the barriers ranking in terms of priority. In addition, in chapter three, section 3.8, literature reviews identified four benefits for solar energy implementation while the empirical data presented in chapter seven sections 7.4 tables 7.3, the research has identified six key benefits for solar energy implementation in Nigeria. The empirical data have also proposed eight strategies that could mitigate the barriers. The key barriers, mitigations strategies and benefits from the empirical study is the research contribution to knowledge.

- In chapter four, section 4.5.2, the researcher adopted Interpretive Structure Modelling to complement the content data analysis in section 4.5.1 and figure 7.1. A new finding reveals that he ISM hierarchy (level I and II), which are socio-cultural, financial, lack of awareness and lack of promotion and market barriers became more significant factors to the barriers for solar energy implementation. This is contrary to the literature review where technical issues appear to be on the top ranking according to the interviewees and literature point of views. The new finding is the research contribution to knowledge.

- In chapter eight section 8.3, the research has integrated the research outcome from chapters 2, 3, 5, 6, 7 and presents them as a framework for facilitating the adoption of solar energy governance in Nigeria.

A journal and a conference papers were published as part of this research study (See Appendix A).

9.4 Recommendations

For Decisions Makers

- The Nigerian government has made a tremendous commitment to transform the entire power sector from Power Holding Company of Nigeria (PHCN) to a public private partnership (GENCOs, TCN and DISCOs). The power sector reforms also stipulated the need to integrate energy mix options by generating electricity from all sources and integrating same to the conventional source. More importantly, among the EPSRA objective, is the PPPs allowing the private sector to participate in the generation and distribution of electricity from all sources to support the national grids. It is, therefore, a collective effort between government MDAs and the private investors to stimulate synergy and partnership to effectively harness the abundant energy from solar to support the national grids and to meet up the high demand of electricity in the country.

- The current study findings revealed that some of the major challenges in the power sector included short-term policies, monopoly and corruption practices throughout the industry. The Power Sector Reform Act of 2005 has broken the monopoly chain, private and public participants now have the opportunity to invest and improve the provision and supply of electricity from all sources. While the generation and distribution companies are now public, the transmission company of Nigeria also needs to be privatised to public entity in order to allow different interested investors to take over the ownership of the company to improve efficiency and effectiveness of service delivery.

- The Electric Power Sector Reform Act proposed in 2001, deliberated in 2002, 2003, reviewed and approved end of 2003 and early 2004 and the Act was enacted into law

in 2005. However, the energy mix projects proposed, contracted and completed between 2005 and 2018 are evident with only a slow progress. It is therefore apparent, government and all stakeholders consider imposing policies and procedures for contracting, solar energy projects to qualified, fit and prospective contractors where monitoring and evaluation will be imposed, payment terms should work hand in hand with the progress achieved from starts to completion. Also, a standard of good and quality of materials used is specified and complied with standard organisations to meet the equipment operation effectiveness and potentials.

- The current study results suggest that the solar energy implementation process is still in its first stage at a slow progress due to many barriers as identified in this study. Taken into consideration the commitment by both government and the private sector participation, many solar mini projects and micro projects are underway in early stages. It is therefore suggested that the private sector together with public MDAs design and implement holistic, long-term policies that supports solar energy promoters, marketers, panels manufacturers and importers, storage facilities, manufacturers, technicians and engineers that are associated with solar energy installations and applications. There is a need for the collaborative stakeholders to engage and emulate good practices for solar energy initiatives with lessons from most successful solar energy users in the world.

- The study identified quite a number of factors that fuelled the need for solar energy initiatives to be implemented and the study also revealed that Nigeria is located on the sunshine belt in Sub-Sahara African countries. It is therefore recommended that the stakeholders take a holistic step to harness the solar energy potentials available throughout the year to support the energy supply, especially rural communities where access to electricity is limited. This is an opportunity for standalone solar energy

systems for small communities that are not connected to the national grid where youth and petty traders engages in socio-economic activities.

Recommendations for Academics

To enhance and strengthen the quality of the research framework for facilitating the adoption solar energy governance, the following are recommended for future work:

- A quantitative data collection approach can be developed in the future using questionnaire survey to find out the relationship between the variables of power sector challenges, key drivers, key barriers and benefits using statistical methods.
- The research adopted the Interpretive Structural Modelling (ISM) in chapter seven, table 7.1. Hence, the ISM method can be explored to further analyse the research outcome in chapter five section 5.2 (the Nigerian power sector challenges), chapter six, table 6.1(key drivers) and chapter seven, table 7.3 (key benefits) for solar energy implementation.

List of References

A consortium lead by Aqua of Saudi Arabia - International Co. For Energy and Water Projects are getting close to be awarded a $ 500 million, 160 MW solar energy recovery project in South Morocco, 2012, AmCham Gulf Cooperation Council (GCC) Project News.

Abam, F.I., Nwankwojike, B.N., Ohunakin, O.S. & Ojomu, S.A. 2014, "Energy resource structure and on-going sustainable development policy in Nigeria: a review", International Journal of Energy and Environmental Engineering, 5 (2), pp. 1-16.

Abdullahi, D., Suresh, S., Renukappa, S. & Oloke, D. 2017, "Key Barriers to the Implementation of Solar Energy in Nigeria: A Critical Analysis", *IOP Conference Series: Earth and Environmental Science,* vol. 83, pp. 12015.

Abound Solar Receives MCS Certification and Enters UK Solar Market, 2011, Energy Business Journal, pp. 119.

Abubakar Sani Sambo Bashir Garba Ismaila Haliru Zarma Mohammed Musa Gaji 2012, "Electricity Generation and the Present Challenges in the Nigerian Power Sector", *Journal of energy and power engineering,* vol. 6, no. 7, pp. 1050-1059.

Abuzeinab, A., Arif, M. & Qadri, M.A. 2017, "Barriers to MNEs green business models in the UK construction sector: An ISM analysis", *Journal of cleaner production,* vol. 160, pp. 27-37.

Adaramola, M.S. & Paul, S.S. 2017, "Economic Analysis and Potential Feed-in Tariff of Grid-Connected PV Systems in Nigeria", *Environmental progress & sustainable energy,* vol. 36, no. 1, pp. 305-314.

Adebayo, A.V., Ainah, P.K. & Apata, O. 2020, "The Insight and Foresight of The Nigerian Power Transmission System: An Overview", IEEE, pp. 1.

Adedokun, A 2015, 'Can electricity consumption be useful in predicting Nigerian economic growth? Evidence for error correction model', OPEC Energy Review, 39 (2), pp. 125-140.

Adesanya, A.A. & Schelly, C. 2019, "Solar PV-diesel hybrid systems for the Nigerian private sector: An impact assessment", Energy Policy, vol. 132, pp. 196-207.

African Development Bank Group - Power - Deals and Alliances Profile. 2015. London: Global Data Ltd.

African Development Bank Group (ADBG) (2015) Economic Report on Nigeria: Nigerian Country Office (Online) [Accessed 03 July 2016]. Available at: http://www.afdb.org/fileadmin/uploads/afdb/Documents/Publications/ORNG_Economic_Report_on_Nigeria_Special_Edition_2015.pdf.

Ahmed, V., Opoku, A. & Aziz, Z. 2016, Research methodology in the built environment: a selection of case studies, Routledge, Abingdon.

Ahmed: FG Reconstituted NBET Board to Stabilise Power Sector 2020, SyndiGate Media Inc, Lagos.

Aigbovo, O. & Ogboka, E. 2016, "Electric Power Sector Reform Act 2005 and the Development of Renewable Energy in Nigeria", *Renewable energy law and policy,* vol. 7, no. 1, pp. 20-29.

Airoboman, A.E., Ogujor, E.A. & Kokakwu, I. 2017, "Reliability analysis of power system network: A case study of transmission company of Nigeria, Benin City", IEEE, pp. 99.

Akinbami, J.K. 2001, "Renewable energy resources and technologies in Nigeria: present situation, future prospects and policy framework", Mitigation and Adaptation Strategies for Global Change, 6 (2), pp. 155-182.

Akinwale, Y.O., Ogundari, I.O., Ilevbare, O.E. and Adepoju, A.O., 2014. A Descriptive Analysis of Public Understanding and Attitudes of Renewable Energy Resources towards Energy Access and Development in Nigeria. International Journal of Energy Economics and Policy, 4 (4), pp. 636-646.

Akinyele, D.O., Rayudu, R.K. & Nair, N.K.C. 2015, "Global progress in photovoltaic technologies and the scenario of development of solar panel plant and module performance estimation − Application in Nigeria", *Renewable & sustainable energy reviews,* vol. 48, pp. 112-139.

Akinyemi, O., Ogundipe, A. & Alege, P. 2012, *Energy Supply and Climate Change in Nigeria*.

Akuru, U.B. & Okoro, O.I. 2011, "A Prediction on Nigeria's Oil Depletion Based on Hubbert's Model and the Need for Renewable Energy", *ISRN renewable energy,* vol. 2011, pp. 1-6.

Akuru, U.B., Onukwube, I.E., Okoro, O.I. & Obe, E.S. 2017, "Towards 100% renewable energy in Nigeria", Renewable and Sustainable Energy Reviews, 71, pp. 943-953.

Alao, O. & Awodele, K. 2018, "An Overview of the Nigerian Power Sector, the Challenges of its National Grid and Off-Grid Development as a Proposed Solution", IEEE, pp. 178.

Aliyu, A.S., Dada, J.O. & Adam, I.K. 2015, "Current status and future prospects of renewable energy in Nigeria", Renewable and Sustainable Energy Reviews, 48, pp. 336-346.

Aliyu, A.S., Ramli, A.T. & Saleh, M.A. 2013, "Nigeria electricity crisis: Power generation capacity expansion and environmental ramifications", Energy, 61, pp. 354-367.

Amankwah, E. 2015, "Solar Energy: A Potential Source of Energy for Agricultural and Rural Development in Ghana", *Journal of Agriculture and Ecology Research International,* vol. 3, no. 4, pp. 131-140.

Amankwah-Amoah, J 2015, 'Solar Energy in Sub-Saharan Africa: The Challenges and Opportunities of Technological Leapfrogging', Thunderbird International Business Review, 57(1), pp. 15-31.

Amobi, M.C. 2007, "Deregulating the electricity industry in Nigeria: Lessons from the British reform", *Socio-economic planning sciences,* vol. 41, no. 4, pp. 291-304.

Andresen, G., Rodriguez, R., Becker, S. and Greiner, M. (2014). The potential for arbitrage of wind and solar surplus power in Denmark. Energy, 76, pp.49-58.

Ang, B.W., Choong, W.L. & Ng, T.S. 2015, "Energy security: Definitions, dimensions and indexes", *Renewable & sustainable energy reviews,* vol. 42, pp. 1077-1093.

Ariyomo - Fixing Electricity Will Change the Trajectory of Nigeria's History [interview] 2014, SyndiGate Media Inc, Washington.

Arowolo, W. & Perez, Y. 2020, "Market reform in the Nigeria power sector: A review of the issues and potential solutions", *Energy policy,* vol. 144, pp. 111580.

Arowolo, W., Blechinger, P., Cader, C. & Perez, Y. 2019, "Seeking workable solutions to the electrification challenge in Nigeria: Minigrid, reverse auctions and institutional adaptation", Energy Strategy Reviews, 23, pp. 114-141.

Asumadu-Sarkodie, S., Asantewaa Owusu, P. & Sustainable Environment and Energy Systems, Middle East Technical University—Northern Cyprus Campus, Kalkanli, Guzelyurt, TRNC 99738/Mersin 10, Turkey 2016, "A review of Ghana's solar energy potential", *AIMS energy,* vol. 4, no. 5, pp. 675-696.

Atsu, D., Agyemang, E.O. & Tsike, S.A.K. 2016, "Solar electricity development and policy support in Ghana", *Renewable & sustainable energy reviews,* vol. 53, pp. 792-800.

Audu, M.O. & Okeke, F.N. 2019, "Investigation of possible connections between solar activity and climate change in Nigeria", *SN Applied Sciences,* vol. 1, no. 2, pp. 1-7.

Babikir, M.H., Chara-Dackou, V.S., Njomo, D., Barka, M., Khayal, M.Y., Legue, D.R.K. & Gram-Shou, J.P. 2020, "Simplified Modeling and Simulation of Electricity Production from a Dish/Stirling System", *International journal of photoenergy,* vol. 2020, pp. 1-14.

Bamisile, O., Dagbasi, M., Babatunde, A. & Ayodele, O. 2017, "A review of renewable energy potential in Nigeria; solar power development over the years", *Engineering and Applied Science Research (EASR),* vol. 44, no. 4, pp. 242-248.

Bamisile, O., Huang, Q., Xu, X., Hu, W., Liu, W., Liu, Z. & Chen, Z. 2020, "An approach for sustainable energy planning towards 100 % electrification of Nigeria by 2030", *Energy (Oxford),* vol. 197, pp. 117172.

Berg, B.L and Lune, H. (2004) Qualitative research methods for social sciences (Vol. 5). Boston: Pearson.

Berg, B.L. & Lune, H. 2014, Qualitative research methods for the social sciences, Eighth; Pearson new international, Harlow, Essex: Pearson.

Bernard, H.R. (2011) Research Methods in Anthropology, 5th Ed. London: AltaMira Press.

Bhandari, R. and Stadler, I. (2015). Grid parity analysis of solar photovoltaic systems in Germany using experience curves. Solar Energy, 83(9), pp.1634-1644.

Bhosale, V.A. & Kant, R. 2016, "An integrated ISM fuzzy MICMAC approach for modelling the supply chain knowledge flow enablers", *International journal of production research,* vol. 54, no. 24, pp. 7374-7399.

Blaikie, N. (2000) Designing Social Research, Cambridge: Polity.

Blythe, S. 2016, "Coordination and Transfer across the Metagenre of Secondary Research", College Composition and Communication, 67(4), pp. 607.

Boampong, R. & Brown, D.P. 2020, "On the benefits of behind-the-meter rooftop solar and energy storage: The importance of retail rate design", *Energy economics,* vol. 86, pp. 104682.

Bongoni, R., Verkerk, R., Dekker, M. & Steenbekkers, B. 2015, "Evaluation of research methods to study domestic food preparation", British Food Journal,117(1), pp. 7-21.

Bryman, A. (2007). Barriers to Integrating Quantitative and Qualitative Research. Journal of Mixed Methods Research, (1), 8-22.

Bugaje, I.M. 2006, "Renewable energy for sustainable development in Africa: a review", Renewable and Sustainable Energy Reviews, 10 (6), pp. 603-612.

Burnard, P., Gill, P., Stewart, K., Treasure, E., and Chadwick, B. (2008). Analysing and presenting qualitative 0data. British dental journal, 204(8), 429-432.

Burney, S. M. A. (2008) Inductive & Deductive Research Approach. Online Resources. Available at:http://www.drburney.net/INDUCTIVE%20&%20DEDUCTIVE%20RESEARCH%20APPROACH%2006032008. (Accessed: 20th March 2018).

Burns, J.E. & Kang, J. 2012, "Comparative economic analysis of supporting policies for residential solar PV in the United States: Solar Renewable Energy Credit (SREC) potential", *Energy policy,* vol. 44, pp. 217-225.

CBD Energy Limited to Develop Rooftop Solar Installations in 22 UK Schools, 2014, Energy Weekly News, pp. 83.

CBN (2015) Annual Economic Report for 2015.

Cervigni, R., Rogers, J.A. & Henrion, M. 2013;2015;, *Low-carbon development: opportunities for Nigeria,* THE WORLD BANK, Herndon.

Chakraborty, P.R., Agarwal, A.K., Powar, S. & Tyagi, H. 2020, *Solar Energy: Systems, C First Solar: Sustainable Solar Energy Industry Has Potential to Create Jobs, Local Value 2013, , Athena Information Solutions Pvt. Ltd.*

Chandra, S. & Sharma, M.K. 2013, Research methodology, Oxford: Alpha Science International.

Changing Dynamics of the Sub Sahara Africa Power Sector - Increasing Investments by Foreign Players to Drive Growth in the Region 2012, PR Newswire Association LLC, New York.

Charles, A., 2014. How is 100% renewable energy possible in Nigeria? Global Energy Network Institute (GENI), 1(619), pp. 595-0139.

Chirambo, D. 2018, "Towards the achievement of SDG 7 in sub-Saharan Africa: Creating synergies between Power Africa, Sustainable Energy for All and climate finance in-order to achieve universal energy access before 2030", Renewable and Sustainable Energy Reviews, vol. 94, pp. 600-608.

Collis, J. & Hussey, R. 2014, *Business research: a practical guide for undergraduate & postgraduate students,* Fourth edn, Palgrave Macmillan, Basingstoke.

Consumer Group: Even as Energy Demand Increased, Georgia's Emissions Fell by Roughly 95 Percent 2019, , Business Wire, Inc, New York.

Cope, D.G. 2014, "Methods and meanings: credibility and trustworthiness of qualitative research", Oncology nursing forum,41(1), pp. 89-91.

Corbin, J., and Strauss, A. (Eds.). (2008). Basics of qualitative research: Techniques and procedures for developing grounded theory. Sage.

Cororaton, C.B. & Timilsina, G.R. 2014, "Biofuels and Poverty" in Springer New York, New York, NY, pp. 79-89.

Creswell, J. W. (2003): Research Design: qualitative, quantitative and mixed methods Approaches; 2nd Ed. London: Sage Publications.

Creswell, J.W. 2013, *Qualitative inquiry & research design: choosing among five approaches,* 3rd edn, SAGE, Thousand Oaks, CA.

Creswell, J.W. 2014, Research design: qualitative, quantitative, and mixed methods approaches, Fourth, international student edition., London: SAGE.

Crist, J.D. & Tanner, C.A. 2003, "Interpretation/Analysis Methods in Hermeneutic Interpretive Phenomenology", Nursing Research,52(3), pp. 202-205.

Cross, W.E. & Galletta, A. 2013, Qualitative Studies in Psychology: Mastering the Semi-Structured Interview and Beyond: From Research Design to Analysis and Publication. London: NYU Press.

Crowther D and Lancaster G (2008) Research methods: a concise introduction to research in management and business consultancy. New York: Routledge.

Daniela Dal Forno Kinalski, Cristiane Cardoso de Paula, Stela Maris de Mello Padoin, Neves, E.T., Kleinubing, R.E. & Cortes, L.F. 2017, "Focus group on qualitative research: experience report", Revista Brasileira de Enfermagem. 702, pp. 424.

Davies, M. & Hughes, N. 2014, Doing a successful research project: using qualitative or quantitative methods. 2nd ed. Basingstoke: Palgrave Macmillan.

Davies, M. & Hughes, N. 2014, *Doing a successful research project: using qualitative or quantitative methods,* Second edn, Palgrave Macmillan, Basingstoke.

De Langhe R, Schliesser E. Evaluating Philosophy as Exploratory Research. Metaphilosophy, 48(3):227-44.

DeMauro, S.B., Cairnie, J., D'Ilario, J., Kirpalani, H. & Schmidt, B. 2014, "Honesty, trust, and respect during consent discussions in neonatal clinical trials", Pediatrics. 134(1), pp. e1-e3.

Denscombe, M. (2010) The Good Research Guide: For Small-Scale Social Research Projects: For small-scale social research projects. 4th Ed. London: McGraw-Hill International.

Denscombe, M. (2017) The Good Research Guide: For small-scale social research projects. 6th Ed. London: Open University Press: McGraw-Hill Education.

Denscombe, M. 2014, The good research guide: for small-scale social research projects. 5th Ed. Open University Press, Maidenhead.

Denzin N and Lincoln Y (2005): Introduction: The discipline and practice of qualitative research; Handbook of Qualitative Research; 2nd edition; Thousand Oaks, CA: Sage.

Denzin, N. K. and Lincoln, Y. S. (2018) The SAGE Handbook of Qualitative Research. 5th ed. London: SAGE Publication.

discussion", Renewable and Sustainable Energy Reviews, 69, pp. 1170-1181.

Duke, R. D., Jacobson, A., & Kammen, D. M., (2015). Photovoltaic module quality in the Kenyan solar home systems market. Energy Policy. (6), 477–499.

Dumay, J. & Cai, L. 2015, "Using content analysis as a research methodology for investigating intellectual capital disclosure: A critique", *Journal of intellectual capital,* vol. 16, no. 1, pp. 121-155.

Duriau, V.J., Reger, R.K. & Pfarrer, M.D. 2007, "A Content Analysis of the Content Analysis Literature in Organization Studies: Research Themes, Data Sources, and Methodological Refinements", Organizational Research Methods,10(1), pp. 5-34.

Edkins, M., Marquard, A., & Winkler, H. (2014). South Africa's renewable energy policy roadmaps. Washington, DC: United Nations Environment Programme Research Project.

Edomah, N., Foulds, C. & Jones, A. 2016, "The Role of Policy Makers and Institutions in the Energy Sector: The Case of Energy Infrastructure Governance in Nigeria", *Sustainability (Basel, Switzerland),* vol. 8, no. 8, pp. 829.

Edomah, N., Foulds, C. & Jones, A. 2017, "Policy making and energy infrastructure change: A Nigerian case study of energy governance in the electricity sector", *Energy policy,* vol. 102, pp. 476-485.

Ehi-Uujamhan, O. 2016, *The complements towards developing a new risk management framework and its applicability to the Nigerian power sector*, Aston University.

Eleftheriadis, I.M. & Anagnostopoulou, E.G. 2015, "Identifying barriers in the diffusion of renewable energy sources", Energy Policy, 80, pp. 153-164.

Elmustapha, H. & Hoppe, T. 2020, "Challenges and opportunities of business models in sustainable transitions: Evidence from solar energy niche development in Lebanon", *Energies (Basel),* vol. 13, no. 3, pp. 670.

Elum, Z.A. & Mjimba, V. 2020, "Potential and challenges of renewable energy development in promoting a green economy in Nigeria", *Africa review (New Delhi),* vol. 12, no. 2, pp. 172-191.

Emetere, M.E. & Akinyemi, M.L. 2016, "Prospects of solar energy in the coastal areas of Nigeria", AIP Conference Proceedings, 1705(1).

Emodi, N.V. & Yusuf, S.D. 2015, "Improving Electricity Access in Nigeria: Obstacles and the Way Forward", *International journal of energy economics and policy,* vol. 5, no. 1, pp. 335-351.

Emodi, N.V. 2016, *Energy Policies for Sustainable Development Strategies: The Case of Nigeria,* Springer Singapore Pte. Limited, Singapore.

Emodi, N.V. and Boo, K.J., 2015. Sustainable energy development in Nigeria: Current status and policy options. Renewable and Sustainable Energy Reviews, 51, pp.356-381.

Enkhardt, S. 2020 Global PV capacity additions hit 115 GW in 2019, says IEA, PV Magazine (ONLINE). Available at: https://www.pv-magazine.com/2020/05/01/global-pv-capacity-additions-hit-115-gw-in-2019-says-iea/. [Accessed 25 January 2021].

Farris, D.R. & Sage, A.P. 1975, "On the use of interpretive structural modeling for worth assessment", *Computers & electrical engineering,* vol. 2, no. 2, pp. 149-174.

Federal Government Promoting Private Sector Participation to Accelerate Power Sector Reform in Nigeria. 2012. London: Global Data Ltd.

Federal Republic of Nigeria (FRN) (2013). The Midterm report of the Transformation Agenda 2011–2013: taking stock, moving forward. Abuja: FRN.

Fellows, R. and Liu, A. (2003) Research Methods for Construction, Blackwell Science Ltd.

First Solar: Sustainable Solar Energy Industry Has Potential to Create Jobs, Local Value 2013, , Japan Corporate News Network, Tokyo.

Flick, U. 2015, Introducing research methodology: A beginner's guide to doing a research project. 2nd Ed. London: SAGE.

Fluri, T.P. 2009, "The potential of concentrating solar power in South Africa", *Energy policy,* vol. 37, no. 12, pp. 5075-5080.

Galletta, A. & Cross, W.E. 2013, Mastering the Semi-Structured Interview and Beyond: From Research Design to Analysis and Publication. New York: NYU Press.

Galliers, R.D. & Huang, J.C. 2012, "The teaching of qualitative research methods in information systems: an explorative study utilizing learning theory", European Journal of Information Systems,21(2), pp. 119-134.

Gatugel Usman, Z, Abbasoglu, S, Tekbiyik Ersoy, N, & Fahrioglu, M 2015, 'Transforming the Nigerian power sector for sustainable development', Energy Policy, 87, pp. 429-437.

Gibbs, G. R. (2002). Qualitative data analysis: Explorations with NVivo. Open University.

Giwa, A., Alabi, A., Yusuf, A. & Olukan, T. 2017, "A comprehensive review on biomass and solar energy for sustainable energy generation in Nigeria", Renewable and Sustainable Energy Reviews, 69, pp. 620-641.

Graneheim, U. H., & Lundman, B. (2004) Qualitative content analysis in nursing research: concepts, procedures and measures to achieve trustworthiness. Nurse education today, 24(2), pp. 105-112.

Guest, G., MacQueen, K. & Namey, E. 2012, "Validity and Reliability (Credibility and Dependability) in Qualitative Research and Data Analysis" Thousand Oaks: SAGE Publications, Inc. pp. 79.

Gujba, H., Mulugetta, Y. & Azapagic, A. 2011, "Power generation scenarios for Nigeria: An environmental and cost assessment", *Energy policy,* vol. 39, no. 2, pp. 968-980.

Habib, M.M., Pathik, B.B. & Maryam, H. 2014, Research methodology - contemporary practices: guidelines for academic researchers. 1st Ed. Cambridge: Scholars Publishing, Newcastle upon Tyne.

Hansen, N., He, X., Griggs, R. & Moshammer, K. 2019, "Knowledge generation through data research: New validation targets for the refinement of kinetic mechanisms", Proceedings of the Combustion Institute, vol. 37, no. 1, pp. 743-750.

Hartley, R. 2011, "Qualitative Research: Participant Observation, Focus Groups, and Case Studies". Thousand Oaks: SAGE Publications, pp. 267.

Heller, A. (2015). 15 Years of R&D in central solar heating in Denmark. Solar Energy, 69(6), pp.437-447.

Hennink, M.M., Hutter, I. & Bailey, A. 2011, Qualitative research methods. London: SAGE Publication Ltd.

Holden, M. T. and Lynch, M. (2004): Choosing the appropriate methodology: understanding research philosophy [online]. Available at: http://repository.wit.ie/1466/1/Choosing_the_Appropriate_Methodology_Understanding_Research_Philosophy_(RIKON_Group).pdf [Accessed 12 January 2018].

Horn, R. (2010) Researching and Writing Dissertations – A Complete Guide for Business and Management Students' CIPD: London.

Howe, G. & McKay, A. 2007, "Combining Quantitative and Qualitative Methods in Assessing Chronic Poverty: The Case of Rwanda", World Development, 35(2), pp. 197-211.

Howitt, D. and Cramer, D. (2010) Introduction to Research Methods in Psychology.3rd edition. New Jersey: Prentice Hall.

Hsieh H, Shannon SE. (2005) Three Approaches to Qualitative Content Analysis. Qualitative Health Research. 15(9), 1277-88.

Hubert, P. 2013, "Solar Energy Industry : Challenges & Opportunities on the Path to Financial Sustainability" in WIP.

Ijewereme, O.B. 2015, "Anatomy of Corruption in the Nigerian Public Sector: Theoretical Perspectives and Some Empirical Explanations", *SAGE open,* vol. 5, no. 2, pp. 215824401558118.

İkiz, A.S. 2014, "Economic benefits of solar energy for Turkey", *International Journal of Innovation and Knowledge Management in the Middle East and North Africa,* vol. 3, no. 3/4, pp. 341.

Ikoh, M.U. 2018, "Nigerian corruption complex: rethinking complementarities to curative measures", *Journal of financial crime,* vol. 25, no. 2, pp. 576-588.

Ikpe, E. & Torriti, J. 2018, "A means to an industrialisation end? Demand Side Management in Nigeria", Energy Policy, vol. 115, pp. 207-215.

Ilic, V. 2011, "Prvi Aleksandrinski Tekst O Analizi Sadrzaja U Sociologiji/The First Alexandrian Text-type on Content Analysis", Sociologija, 53(4), pp. 453.

Imam, M.I., Jamasb, T. & Llorca, M. 2019, "Sector reforms and institutional corruption: Evidence from electricity industry in Sub-Saharan Africa", Energy Policy, vol. 129, pp. 532-545.

India at 90th rank in terms of energy security, access: WEF 2016, THG Publishing Private Limited, Chennai.

Iniesta, J. and Barroso, M. (2015). Assessment of Offshore Wind Energy Projects in Denmark. A Comparative Study with Onshore Projects Based on Regulatory Real Options. J. Sol. Energy Eng, 137(4), p.041009.

Ivey, J. 2013, "Interpretive phenomenology", Pediatric nursing, 39(1), pp. 27.

Izquierdo, S., Montañés, C., Dopazo, C. and Fueyo, N. (2014). Roof-top solar energy potential under performance-based building energy codes: The case of Spain. Solar Energy, 85(1), pp.208-213.

Jackson, R. 2011, "The interpretive approach as a research tool: inside the REDCo project", *British journal of religious education,* vol. 33, no. 2, pp. 189-208.

Jacob, J., PhD. And Abubakar, S.O., PhD., 2015. Power Sector Viability and Development in Nigeria: Problems and Prospects. African Journal of International Affairs & Development, 18(1), pp. 37-50.

Jockusch, E.L., Martínez-Solano, I. & Timpe, E.K. 2015, "The effects of inference method, population sampling, and gene sampling on species tree inferences: an empirical study

in slender salamanders (Plethodontidae: Batrachoseps)", Systematic biology, 64(1), pp. 66-83.

Johnston, J. 2010, "Qualitative research methods", Radiologic technology, 82(2), pp. 188.

Joseph, A. (2014) Research Design and their types. [ONLINE]. Available at: https://www.slideshare.net/arunjosephs/research-design-and-types-of-research-design-arun-joseph-mphil-ppt. [Accessed 21 March 2018].

Kalogirou, S.A. 2004, "Environmental benefits of domestic solar energy systems", *Energy conversion and management,* vol. 45, no. 18-19, pp. 3075-3092.

Kannan, D., Diabat, A. & Shankar, K.M. 2014, "Analyzing the drivers of end-of-life tire management using interpretive structural modeling (ISM)", *International journal of advanced manufacturing technology,* vol. 72, no. 9, pp. 1603-1614.

Kanters, J. & Horvat, M. 2012, "Solar Energy as a Design Parameter in Urban Planning", *Energy procedia,* vol. 30, pp. 1143-1152.

Kar, S.K. & Sharma, A. 2015, "Wind power developments in India", Renewable and Sustainable Energy Reviews, 48 pp. 264-275.

Kenya Ministry of Energy. (2013). Sectional Paper No. 4 of 2013 on energy. Nairobi, Kenya: Government Printers.

Ketchen, D.J. & Bergh, D.D. 2004, Research methodology in strategy and management, Elsevier JAI, Amsterdam; Oxford

Keyur, Dr. et al. 2014. Overview of Validation and Basic Concepts of Process Validation, Scholars Academic Journal of Pharmacy (SAJP) Sch. Acad. J. Pharm. 3(2): 178-190 20.

Khan, S.N. 2014, "Qualitative Research Method: Grounded Theory", International Journal of Business and Management, 9(11).

Khan, U. & Haleem, A. 2015, "Improving to Smart Organization: An integrated ISM and fuzzy-MICMAC modelling of barriers", *Journal of manufacturing technology management,* vol. 26, no. 6, pp. 807-829.

Kiplagat, J.K., Wang, R.Z. & Li, T.X. 2011, "Renewable energy in Kenya: Resource potential and status of exploitation", *Renewable & sustainable energy reviews,* vol. 15, no. 6, pp. 2960-2973.

Kirshenblatt-Gimblett, B. (2006) Part 1, What Is Research Design? The Context of Design. Internet: Available: http://www.nyu.edu/classes/bkg/methods/005847ch1.pdf. [Accessed: 16 December 2017].

Knight, A. and Ruddock, L. (2009): Advanced research methods in the built environment, Chichester (U.K.): Wiley-Blackwell Publisher.

Kondracki, N. and Wellman, N.S. (2002). Content analysis: Review of methods and their applications in nutrition education. of Nutrition Education and Behaviour, 34, 224-230.

Koocher, G.P. 2014, "Research Ethics and Private Harms", Journal of Interpersonal Violence, 29(18), pp. 3267-3276.

Krippendorf, K. (1980). Content analysis: An introduction to its methodology. Beverly Hills, California: SAGE Publications Ltd.

Kumar, R. 2014, Research methodology: a step-by-step guide for beginners, 4th Ed. London: SAGE Publications.

Lancaster, G. (2007) Research methods in management. London: Routledge.

Lara-Fanego, V., Ruiz-Arias, J., Pozo-Vázquez, D., Santos-Alamillos, F. and Tovar-Pescador, J. (2016). Evaluation of the WRF model solar irradiance forecasts in Andalusia (southern Spain). Solar Energy, 86(8), pp.2200-2217.

Lather, A.S. & Kaur, S. 2019, "MODELLING THE EFFECTIVE E-HRM ENABLERS USING ISM AND MICMAC APPROACH", *Delhi Business Review,* vol. 20, no. 1, pp. 1-21.

Laurent, C. & Whitehouse, K. 2017, "THE POWER OF RENEWABLE ENERGY: Development and finance options for local governments", *Public management,* vol. 99, no. 10, pp. 6.

Lawson, D., Hulme, D. & Muwonge, J. 2008, "Combining quantitative and qualitative research to further our understanding of poverty dynamics: Some methodological considerations", International Journal of Multiple Research Approaches, 2(2), pp. 191-204.

Leedy P. D and Ormrod J. E (2001): Practical research planning and design; 7th Ed. New Jessy: Prentice-Hall, Upper Saddle River.

Leedy, P. D (1997): Practical Research Planning and Design, 6th Ed. London: Prentice-Hall Inc.

Leung, L. 2015, "Validity, reliability, and generalizability in qualitative research", Journal of family medicine and primary care, 4(3), pp. 324-327.

Li, P., Li, X., Zhang, L. & Dai, L. 2018, "A validation research on fuzzy logic-AHP-based assessment method of operator's situation awareness reliability", Safety Science.

Liamputtong, P. and Ezzy, D. (2005) Qualitative research methods, South Melbourne: Oxford University Press.

Lodico M., Spaulding D. and Voegtle K. (2010), Methods in educational research: From theory to practice, San Francisco, CA: John Wiley & Sons.

Lotz, M. & Brent, A.C. 2014, "Investigating the financial closure of projects within the South African renewable energy independent power producer procurement programme", *South African journal of industrial engineering,* vol. 25, no. 3, pp. 57-68.

Lucko, G. & Rojas, E.M. 2010, "Research Validation: Challenges and Opportunities in the Construction Domain", Journal of Construction Engineering and Management, vol. 136, no. 1, pp. 127-135.

Luthra, S., Kumar, S., Garg, D. & Haleem, A. 2015, "Barriers to renewable/sustainable energy technologies adoption: Indian perspective", Renewable and Sustainable Energy Reviews, 41, pp. 762-776.

Macfarlane, G.J., Jones, G.T., Swafe, L., Reid, D.M. & Basu, N. 2013, "Alternative population sampling frames produced important differences in estimates of association: a case–control study of vasculitis", Journal of Clinical Epidemiology, 66(6), pp. 675-680.

Mainzer, K., Fath, K., McKenna, R., Stengel, J., Fichtner, W. and Schultmann, F. (2016). A high-resolution determination of the technical potential for residential-roof-mounted photovoltaic systems in Germany. Solar Energy, 105, pp.715-731.

Marshall, B., Cardon, P., Poddar, A. & Fontenot, R. 2013, "Does Sample Size Matter in Qualitative Research? A Review of Qualitative Interviews in Is Research", The Journal of Computer Information Systems,54(1), pp. 11-22.

Masuhara H. 2015. Exploratory Research on Time- and Space-Resolved Spectroscopy and Chemistry. The Chemical Record. 15(6):1153-5.

Matlock, S. 2009, *Climate Change; CO2 Campaign Targets Bingaman Ahead of Key Legislation*, The Santa Fe New Mexican, Santa Fe, N.M.

Maylor H and Blackmon K (2005): Researching business and management; London: Palgrave Macmillan.

Mayring, P. (2000). Qualitative content analysis. Forum: Qualitative Social Research, (ONLINE). Available at: http://www.qualitative-research.net/fqs-texte/2-00/02-00mayring-e.htm. [Accessed 10 March 2018].

McGrath, M. (2016). Ghana solar energy plant set to be Africa's largest [Onlinw]. [Accessed 17 July 2016]. Available at: http://www.bbc.co.uk/news/science-environment-20583663

McGuigan, K. 2011, "Interviews in qualitative research Nigel King Interviews in qualitative research and Christine Horrocks SAGE Publishing. Nurse Researcher,18(3), pp. 45-45.

Meijer, P.C., Oolbekkink, H.W., Meirink, J.A. & Lockhorst, D. 2013, "Teacher research in secondary education: Effects on teachers' professional and school development, and issues of quality", International Journal of Educational Research, 57, pp. 39-50.

Meyer, C. B. (2001) A Case in Case Study Methodology. Field Methods, 13(4), pp. 329–352.

Miller, F.G. & Wertheimer, A. 2010, The ethics of consent: theory and practice, Oxford: Oxford University Press.

Mishra, P. & Behera, B. 2016, "Socio-economic and environmental implications of solar electrification: Experience of rural Odisha", *Renewable & sustainable energy reviews,* vol. 56, pp. 953-964.

Mohammed, S. and Hamilton, K. 2007. Input–Process–Output Model of Team Effectiveness. In: Steven G. Rogelberg Editor, 2007. *Encyclopedia of Industrial and Organizational Psychology*, Thousand Oaks, CA: SAGE Publications, Inc. pp. 354-355 Available at: <http://www.doi.org/10.4135/9781412952651.n136> [Accessed 18 Jan 2021].

Mohammed, Y.S., Kiray, V., Saka, B., Aja, E.A. & Dalhatu, I.I. 2020, "Application of Solar Energy Technologies in Nigeria: Synopsis of Significant Issues and Challenges", IEEE, pp. 1.

Mohammed, Y.S., Mustafa, M.W., Bashir, N. & Mokhtar, A.S. 2013, "Renewable energy resources for distributed power generation in Nigeria: A review of the potential", Renewable and Sustainable Energy Reviews, 22, pp. 257-268.

Monyei, C.G., Adewumi, A.O., Obolo, M.O. & Sajou, B. 2018, "Nigeria's energy poverty: Insights and implications for smart policies and framework towards a smart Nigeria electricity network", Renewable and Sustainable Energy Reviews, vol. 81, pp. 1582-1601.

Morgan, G. 2019, *Energy conflicts abound; 'It's been one body blow after another'*, Postmedia Network Inc, Don Mills, Ont.

Naidoo, A. 2020, "The socio-economic impacts of solar water heaters compared across two communities: A case study of Cato Manor", *Renewable & sustainable energy reviews,* vol. 119, pp. 109525.

Nane, G. 2012, *Corruption, and institutions: the Nigerian electric power sector (1999-2009)*, London South Bank University.

National Bureau of Statistics (NBS) (2013a). Economic outlook for the Nigerian economy (2013–2016).

Neuman, W.L. 2014, Social research methods: qualitative and quantitative approaches, Seventh Pearson new international Edition. Essex: Pearson, Harlow.

Nevin, T. (2014). Is South Africa running out of power? African Business, 310, 26–27.

Nevin, T. (2016). South Africa to build: World's biggest solar energy system. African Business, 386, 26–27.

New Energy and the Environment Study Findings Recently Were Reported by Researchers at University of Malaya (Barriers to Renewable Energy Development: Five Fuel Policy in Malaysia), 2016, China Weekly News, pp. 405.

New Renewable Energy Findings from Obafemi Awolowo University Described, 2014, Energy Weekly News, pp. 366.

Nguyen, T.Q.T. 2015, "Conducting semi-structured interviews with the Vietnamese", Qualitative Research Journal, 15(1), pp. 35-46.

Nigeria,United States : NIGERIAN power sector receives $200m funding from WORLD BANK' 2014, Tenders info News, p. 1.

Nigeria: Federal Government expects to ramp-up power supply to 5000MW' 2014, Tenders info News, p. 1.

Nigeria: MINISTRY OF POWER apply new metering strategy aiming at increasing revenue beyond N144bn annually' 2014, Tenders info News, p. 1.

Nigeria: NERC condemns absence of renewable energy policy in NIGERIA 2014, Athena Information Solutions Pvt. Ltd.

Nigeria: NINE northern states of NIGERIA to get 420MW solar energy 2013, Albawaba (London) Ltd, London.

Nigerian Electricity Development (2019) [ONLINE] Available at: https://nerc.gov.ng/. [Accessed 29 July 2019).

Nigerian Energy Support Programme (nesp) 2016- Procurement of Smart Meters in Tungan Jika [Tender documents: T36804639]. MENA Report.

Nigerian Energy Support Programme (NESP), 2015MENA Report.

Nigerian Energy Support Programme 2016, Procurement of Smart Meters in Tungan Jika. Mena Report.

Nigerian Power Status (2019) [ONLINE] Available at: http://www.energy.gov.ng/index.php?view=article&catid=37:about-ecn&id=21:welcome-staement&format=pdf. [Accessed 29 July 2019].

Nikas, A., Stavrakas, V., Arsenopoulos, A., Doukas, H., Antosiewicz, M., Witajewski-Baltvilks, J. & Flamos, A. 2018;2020;, "Barriers to and consequences of a solar-based energy transition in Greece", *Environmental innovation and societal transitions,* vol. 35, pp. 383-399.

Noble, H. & Smith, J. 2015, "Issues of validity and reliability in qualitative research", Evidence-based nursing, 18(2), pp. 34-35.

Nwanakwere, J.T. & Uzoeto, J. 2019, "Electrical Energy Insecurity and the Performance of the Small and Medium Enterprise Sub-Sector in Nigeria", *Acta Universitatis Danubius. Œconomica,* vol. 15, no. 6, pp. 55-69.

Nwankwo, E.A., Agboeze, M.U. & Nwobi, A.U. 2018, "Community Heritage Resources and Crisis Management in Rural Nigeria", *SAGE open,* vol. 8, no. 2, pp. 215824401878120.

Nwokocha, C.O., Okoro, U.K. & Usoh, C.I. 2018, "Photovoltaics in Nigeria – Awareness, attitude and expected benefit based on a qualitative survey across regions", Renewable Energy, vol. 116, pp. 176-182.

Nwosa, P.I. 2018, "Foreign Direct Investment in Nigeria: Its Role and Importance in Industrial Sector Growth", *Acta Universitatis Danubius. Œconomica,* vol. 14, no. 2, pp. 41-52.

Obeng, G. Y. (2015). Solar photovoltaic rural electrification: Assessing energy poverty and impacts on quality of life in Ghana. Unpublished doctoral thesis, KNUST, Kumasi, Ghana.

Obuah, E. 2010, "Combatting Corruption in Nigeria: The Nigerian Economic and Financial Crimes (EFCC)", *African studies quarterly,* vol. 12, no. 1, pp. 17-44.

Ochonogor, M. & Egbue, O. 2017, "Renewable Energy Adoption: Analysis of Barriers and Opportunities in Nigeria", IIE Annual Conference. Proceedings, pp. 982-987.

Odubiyi, A.O. & Davidson, I.E. 2005, "England and Wales electricity industry - experiences in deregulation", *Journal of Engineering, Design and Technology,* vol. 3, no. 1, pp. 24-29.

Oduntan, O. 2018, *Power, Culture and Modernity in Nigeria: Beyond the Colony,* 1st edn, Routledge, Milton.

Ogbuabor, J.E., Orji, A., Manasseh, C.O. & Nwosu, C.A. 2018, "Poor Natural Resource Utilization as the Bane of Industrialization in Nigeria: Evidence from National Bureau of Statistics Petrol Price Watch", *International journal of economics and financial issues,* vol. 8, no. 3, pp. 175-181.

O'Gorman, K. 2016, "Research philosophy and paradigm" in Goodfellow Publishers Ltd, pp. 59-80.

Ogunmodimu, O. & Okoroigwe, E.C. 2018, "Concentrating solar power technologies for solar thermal grid electricity in Nigeria: A review", Renewable and Sustainable Energy Reviews, vol. 90, pp. 104-119.

Ogunmodimu, O. & Okoroigwe, E.C. 2019, "Solar thermal electricity in Nigeria: Prospects and challenges", Energy Policy, vol. 128, pp. 440-448.

Ohimain, E.I. & Izah, S.C. 2014, "Energy self-sufficiency of smallholder oil palm processing in Nigeria", *Renewable energy,* vol. 63, pp. 426-431.

Ohunakin, O.S., Adaramola, M.S., Oyewola, O.M. & Fagbenle, R.O. 2014, "Solar energy applications and development in Nigeria: Drivers and barriers", Renewable and Sustainable Energy Reviews, 32, pp. 294-301.

Ohunakin, O.S., Adaramola, M.S., Oyewola, O.M. & Fagbenle, R.O. 2015, "Solar radiation variability in Nigeria based on multiyear RegCM3 simulations", Renewable Energy,74, pp. 195-207.

Ohunakin, O.S., Adaramola, M.S., Oyewola, O.M., Matthew, O.J. & Fagbenle, R.O. 2015, "The effect of climate change on solar radiation in Nigeria", Solar Energy, 116, pp. 272-286.

Oikonomou, V., Becchis, F., Steg, L. & Russolillo, D. 2009, "Energy saving and energy efficiency concepts for policy making", *Energy policy,* vol. 37, no. 11, pp. 4787-4796.

Oladipo, K., Felix, A.A., Bango, O., Chukwuemeka, O. & Olawale, F. 2018, "Power Sector Reform in Nigeria: Challenges and Solutions", *IOP conference series. Materials Science and Engineering,* vol. 413, no. 1, pp. 12037.

Olomiyesan, B.M. & Oyedum, O.D. 2016, "Comparative Study of Ground Measured, Satellite-Derived, and Estimated Global Solar Radiation Data in Nigeria", *Journal of solar energy,* vol. 2016, pp. 1-7.

Olukoju, A. 2004, "'Never Expect Power Always': Electricity Consumers' Response to Monopoly, Corruption and Inefficient Services in Nigeria", *African affairs (London),* vol. 103, no. 410, pp. 51-71.

Omer, A. M., (2014). Renewable Energy Technologies and Sustainable Development. International Journal of Energy, Environment and Economics, 22(4), pp. 329-351.

Onasanya, M. 2017, An Evaluation and Development of the Potentials of Photovoltaic Systems for Water Pumping and Electricity Services in Rural Areas of Nigeria, De Montfort University.

Onoshakpor, R.M. 2014, "Maintenance precepts for efficient electricity infrastructure in sub-Saharan Africa: The case of the Nigerian electricity network", The Institute of Electrical and Electronics Engineers, Inc. (IEEE), Piscataway, pp. 1.

Orji, U.J. 2014, "Towards sustainable local content development in the Nigerian oil and gas industry: an appraisal of the legal framework and challenges", *International Energy Law Review,* vol. 32, no. 1, pp. 30.

Oseni MO. 2012. ‘‘Households' access to electricity and energy consumption pattern in Nigeria. Renewable and Sustainable Energy Reviews,16, pp.990–995.

Oseni, M.O. 2012, "Improving households' access to electricity and energy consumption pattern in Nigeria: Renewable energy alternative", Renewable and Sustainable Energy Reviews, 16 (6), pp. 3967-3974.

Osinowo, A.A., Okogbue, E.C., Ogungbenro, S.B. & Fashanu, O. 2015, "Analysis of Global Solar Irradiance over Climatic Zones in Nigeria for Solar Energy Applications", Journal of Solar Energy, pp. 1-9.

Ostrom, E. 2011, "Background on the Institutional Analysis and Development Framework", Policy Studies Journal, vol. 39, no. 1, pp. 7-27.

Ouedraogo, N.S. 2019, "Opportunities, Barriers and Issues with Renewable Energy Development in Africa: a Comprehensible Review", *Current sustainable/renewable energy reports.,* vol. 6, no. 2, pp. 52-60.

Oyedepo, S. O. 2014. Towards achieving energy for sustainable development in Nigeria. Renewable Sustainable Energy Review, 34, pp. 255-272.

Oyedepo, S.O. 2012, "Efficient energy utilization as a tool for sustainable development in Nigeria", International Journal of Energy and Environmental Engineering, 3(1), pp. 1-12.

Oyedepo, S.O. 2012, "On energy for sustainable development in Nigeria", *Renewable & sustainable energy reviews,* vol. 16, no. 5, pp. 2583-2598.

Oyewo, A.S., Aghahosseini, A., Bogdanov, D. & Breyer, C. 2018, "Pathways to a fully sustainable electricity supply for Nigeria in the mid-term future", Energy Conversion and Management, vol. 178, pp. 44-64.

Oyewo, A.S., Aghahosseini, A., Bogdanov, D. & Breyer, C. 2018, "Pathways to a fully sustainable electricity supply for Nigeria in the mid-term future", Energy Conversion and Management, vol. 178, pp. 44-64.

Ozoegwu, C.G., Mgbemene, C.A. & Ozor, P.A. 2017, "The status of solar energy integration and policy in Nigeria", *Renewable & sustainable energy reviews,* vol. 70, pp. 457-471.

Ozughalu, U.M., Ozughalu, U.M., Ogwumike, F.O. & Ogwumike, F.O. 2019, "Extreme Energy Poverty Incidence and Determinants in Nigeria: A Multidimensional Approach", *Social indicators research,* vol. 142, no. 3, pp. 997-1014.

Painuly, J.P. 2001, "Barriers to renewable energy penetration; a framework for analysis", Renewable Energy, 24 (1), pp. 73-89.

Park W, Na O, Chang H. 2016. An exploratory research on advanced smart media security design for sustainable intelligence information system. Multimedia Tools and Applications. 75(11), 6059-70.

Pasqualetti, M.J. 2011, "SOCIAL Barriers to Renewable Energy Landscapes", Geographical Review, 101 (2), pp. 201-223.

Patton, M. Q. (2002). Qualitative research and evaluation methods. Thousand Oaks, CA: SAGE Publications Ltd.

Patton, M.Q. 2015, Qualitative research & evaluation methods: integrating theory and practice, 4th Ed. SAGE, Thousand Oaks, California.

Pazeley, P. (2013) Qualitative Data Analysis: Practical Strategy. London: SAGE Publications Ltd.

Pesch, I. 2018, *Comparative Analysis of China and United States Solar Energy Potential.*

Picardi, C.A. & Masick, K.D. 2014, Research methods: designing and conducting research with a real-world focus, California: SAGE, Thousand Oaks.

Piper, T. & Dutton, W.H. 2010, "The Politics of Privacy, Confidentiality, and Ethics: Opening Research Methods" in The MIT Press.

Pollmann, O., Podruzsik, S. and Fehér, O., 2014. Social acceptance of renewable energy: Some examples from Europe and Developing Africa. Society and Economy, 36 (2), pp. 217-231.

Rau, H.K. & Williams, P.G. 2016, "Dispositional mindfulness: A critical review of construct validation research", Personality and Individual Differences, vol. 93, pp. 32-43.

Redmond, E.C. & Griffith, C.J. 2003, "A comparison and evaluation of research methods used in consumer food safety studies*", International Journal of Consumer Studies*, 27(1), pp. 17-33.

Riti, J.S. & Shu, Y. 2016, "Renewable energy, energy efficiency, and eco-friendly environment (R-E5) in Nigeria", *Energy, Sustainability and Society*, 6 (1), pp. 1-16.

Romero Rodríguez, L., Salmerón Lissén, J.M., Sánchez Ramos, J., Rodríguez Jara, E.Á. & Álvarez Domínguez, S. 2016, "Analysis of the economic feasibility and reduction of a building's energy consumption and emissions when integrating hybrid solar thermal/PV/micro-CHP systems", *Applied energy,* vol. 165, pp. 828-838.

Rosenthal, M. 2016, "Qualitative research methods: Why, when, and how to conduct interviews and focus groups in pharmacy research", *Currents in pharmacy teaching and learning,* vol. 8, no. 4, pp. 509-516

Rowley, J. 2014, "Designing and using research questionnaires", *Management Research Review*, 37(3), pp. 308-330.

Salvatore, J, Turner, G., Boyle, H., Clerici, A. and Ulreich, S. 2013, World Energy Perspective: Cost of Energy technologies, World Energy Council [ONLINE). Available at: www.worldenergy.org. [Accessed 20 March 2017].

Sambo, A.S. and Bala, E.J., 2012. Penetration of Solar Photovoltaic into Nigeria's Energy Supply Mix. In World, Renewable Energy Forum (WREF).

Sarhan, J.G., Xia, B., Fawzia, S., Karim, A., Olanipekun, A.O. & Coffey, V. 2020;2019;, "Framework for the implementation of lean construction strategies using the interpretive structural modelling (ISM) technique: A case of the Saudi construction industry", *Engineering, construction, and architectural management,* vol. 27, no. 1, pp. 1-23.

Saunders, M, Lewis, P., Thornhill, A. (2012) Research Methods for Business Students (eds). Edinburgh Gate, Harlow, England: Pearson Education Limited.

Schelly, C., Price, J., Delach, A., Thapaliya, R. & Leu, K. 2019, "Improving solar development policy and planning through stakeholder engagement: The Long Island Solar Roadmap Project", *The Electricity journal,* vol. 32, no. 10, pp. 106678.

Shaaban M, Petinrin, J. O. 2014. Renewable energy potentials in Nigeria: Meeting rural energy needs. Renewable and Sustainable Energy Reviews, 29, pp.72-84.

Sharife, K. (2014). South African solar panels can solve power dilemma. African Business, 348, 28–30.

Silverman, D. (2011) Interpreting Qualitative Data, 4th ed. London: Sage Publications Limited.

Silverman, D. (2015). Interpreting Qualitative Data. London: Sage Publications Ltd.

Silvi, C. 2008, "History and Future of Renewable Solar Energy", *Development,* vol. 51, no. 3, pp. 409-414.

Silvi, C. 2008, "History and Future of Renewable Solar Energy", *Development,* vol. 51, no. 3, pp. 409-414.

Sinclair, M. (2014). Mainstreaming Solar PV in the USA. Renewable Energy Focus, 9(5), pp.64-70.

Sindhu, S., Nehra, V. & Luthra, S. 2016, "Identification and analysis of barriers in implementation of solar energy in Indian rural sector using integrated ISM and fuzzy MICMAC approach", *Renewable & sustainable energy reviews,* vol. 62, pp. 70-88.

Singh, M.K., Kumar, H., Gupta, M.P. & Madaan, J. 2018, "Competitiveness of Electronics manufacturing industry in India: an ISM–fuzzy MICMAC and AHP approach", *Measuring business excellence,* vol. 22, no. 1, pp. 88-116.

Singh, R.K. & Gupta, A. 2020, "Framework for sustainable maintenance system: ISM–fuzzy MICMAC and TOPSIS approach", *Annals of operations research,* vol. 290, no. 1-2, pp. 643-676.

Sisodia, G.S., Awad, E., Alkhoja, H. & Sergi, B.S. 2020, "Strategic business risk evaluation for sustainable energy investment and stakeholder engagement: A proposal for energy policy development in the Middle East through Khalifa funding and land subsidies", *Business strategy and the environment,* vol. 29, no. 6, pp. 2789-2802.

Sivaprakasam, R., Sivaprakasam, R., Selladurai, V., Selladurai, V., Sasikumar, P. & Sasikumar, P. 2015, "Implementation of interpretive structural modelling methodology as a strategic decision-making tool in a Green Supply Chain Context", *Annals of operations research,* vol. 233, no. 1, pp. 423-448.

Smets, A.H.M. 2016, Solar energy: the physics and engineering of photovoltaic conversion, technologies, and systems, UIT Cambridge, Cambridge.

Snieder, R & Larner, K. (2009) The Art of Being a Scientist: A Guide for Graduate Students and their Mentors, Cambridge University Press.

Solar Photovoltaic PV in the United Kingdom, 2016 Market Outlook to 2030 - Capacity, Generation, Levelized Cost of Energy LCOE, Investment Trends, Regulations and Company Profiles - Research and Markets, 2016, Energy Weekly News, pp. 712.

Somefun, T., Awosope, C., Abdulkareem, A., Ojo, J., Amuta, E. & Sanni, T. 2020, "Cost implications analysis of grid supplied electricity and solar source of electricity in Nigeria", *Telkomnika,* vol. 18, no. 6, pp. 3258-3265.

Sooriyaarachchi, T.M., Tsai, I., El Khatib, S., Farid, A.M. & Mezher, T. 2015, "Job creation potentials and skill requirements in, PV, CSP, wind, water-to-energy and energy efficiency value chains", *Renewable & sustainable energy reviews,* vol. 52, pp. 653-668.

Sovacool, B.K. 2018, "Success and failure in the political economy of solar electrification: Lessons from World Bank Solar Home System (SHS) projects in Sri Lanka and Indonesia", *Energy policy,* vol. 123, pp. 482-493.

Strupeit, L. & Palm, A. 2016, "Overcoming barriers to renewable energy diffusion: business models for customer-sited solar photovoltaics in Japan, Germany and the United States", Journal of Cleaner Production, 123, pp. 124-136.

Studies from Cranfield University in the Area of Renewable Energy Described (Biomass resources and biofuels potential for the production of transportation fuels in Nigeria), 2016, Biotech Week, pp. 210.

Subramoniam, S., Subramoniam, R., Huisingh, D. & Chinnam, R.B. 2013, "Remanufacturing Decision-Making Framework (RDMF): research validation using the analytical hierarchical process", Journal of Cleaner Production, vol. 40, pp. 212-220.

Sundler, A.J., Lindberg, E., Nilsson, C. & Palmér, L. 2019, "Qualitative thematic analysis based on descriptive phenomenology", *Nursing open,* vol. 6, no. 3, pp. 733-739.

Szabó, G.L. & Kalmár, F. 2019, "Investigation of energy and exergy performances of radiant cooling systems in buildings – A design approach", *Energy (Oxford),* vol. 185, pp. 449-462.

Tambari, I.T., Dioha, M.O. & Failler, P. 2020, "Renewable energy scenarios for sustainable electricity supply in Nigeria", *Energy and Climate Change,* vol. 1.

Thomas, E. & Magilvy, J.K. 2011, "Qualitative Rigor or Research Validity in Qualitative Research", Journal for Specialists in Pediatric Nursing, 16(2), pp. 151-155.

Tian, Y. & Zhao, C.Y. 2013, "A review of solar collectors and thermal energy storage in solar thermal applications", *Applied energy,* vol. 104, pp. 538-553.

Tidjani, F.S. & Chandra, A. 2012, "Integration of renewable energy sources and the utility grid with the Net Zero Energy Building in Republic of Chad", IEEE, pp. 1025.

Tracy, S.J. 2013; 2012, Qualitative research methods: collecting evidence, crafting analysis, communicating impact, 1. Aufl. 1st Ed. Chichester: Wiley-Blackwell.

Trochim W.M. and Donnelly J.P (2008): The research methods knowledge base; 3rd ed. USA: Wadsworth Publishing.

Tuohy, D., Cooney, A., Dowling, M., Murphy, K. & Sixsmith, J. 2013, "An overview of interpretive phenomenology as a research methodology", Nurse researcher, 20(6), pp. 17.

Twidell, J. & Weir, A.D. 2015, Renewable energy resources, Third edn, Routledge, Abingdon.

Tyagi, V.V., Rahim, N.A.A., Rahim, N.A. & Selvaraj, J.A./. 2013, "Progress in solar PV technology: Research and achievement", Renewable and Sustainable Energy Reviews, 20, pp. 443-461.

Udebunu, C. 2011, "Nigeria and the Dialectics of Multiculturalism", *OGIRISI: a New Journal of African Studies,* vol. 8, no. 1, pp. 1.

Udoakah N. Y.-O. 2014. Sustainably meeting the energy needs of Nigeria: The renewable options. IEEE International Conference, IEEE, pp. 326-332.

Udoakah, Y.N. & Umoh, M.D. 2014, "Sustainably meeting the energy needs of Nigeria: The renewable options", IEEE, pp. 326.

Ugwoke, B., Adeleke, A., Corgnati, S.P., Pearce, J.M. & Leone, P. 2020, "Decentralized Renewable Hybrid Mini-Grids for Rural Communities: Culmination of the IREP Framework and Scale up to Urban Communities", *Sustainability (Basel, Switzerland),* vol. 12, no. 18, pp. 7411.

Ulsrud, K., Winther, T., Palit, D., Rohracher, H. & Sandgren, J. 2011, "The Solar Transitions research on solar mini-grids in India: Learning from local cases of innovative socio-technical systems", *Energy for sustainable development,* vol. 15, no. 3, pp. 293-303.

Umoh, E.A. & Lugga, A.A. 2019, "Contextualizing hazard mitigation policy for electricity grids in the Sudan Sahel Region of Nigeria", *Energy policy,* vol. 124, pp. 135-143.

United Nations Development Programme. Sustainable development goals (SDGs). (http://www.undp.org/globalgoals) [accessed 06/02/2017].

Usman, A. 2013, "Determinants of Electricity Consumers Satisfaction in Selected Electricity Distribution Zones in Nigeria: Implications for Regulatory Activities", *Journal of Asian business strategy,* vol. 3, no. 6, pp. 103.

Uzonwanne, G 2013, 'The political economy of development in weak states, an institutional analysis of the Nigerian State', International Journal of Social Economics, 40(1), pp. 4-25.

Vaismoradi, M., Turunen, H. & Bondas, T. 2013, "Content analysis and thematic analysis: Implications for conducting a qualitative descriptive study", *Nursing & health sciences,* vol. 15, no. 3, pp. 398-405.

Vaughan, A. (2016). Africa's largest solar power plant to be built in Ghana. The Guardian [Online]. [Accessed 12 June 2016]. Available at: http://www.theguardian.com/environment/2016/dec/04/africa-largest-solar-power-plant-ghana

Verbruggen, A., Fischedick, M., Moomaw, W., Weir, T., Nadaï, A., Nilsson, L.J., Nyboer, J. & Sathaye, J. 2010;2009;, "Renewable energy costs, potentials, barriers: Conceptual issues", *Energy policy,* vol. 38, no. 2, pp. 850-861.

Vogt, W.P. 2014, Selecting the right analyses for your data: quantitative, qualitative, and mixed methods, 1st Ed. New York: The Guilford Press.

Wang, U. (2016). The promise of South Africa as a new solar frontier[Online]. [Accessed 06 July 2016]. Available at: http://www.renewableenergyworld.com/rea/news/article/2016/12/the-promise-of-south-africa-as-a-new-solar-frontier.

Wang, W., Ji, J., Yue, Z., Zhang, D., Tian, H. & Zhao, H. 2016, "Research on Secondary Impact Safety of Train Driver based on THUMS Dummy", MATEC Web of Conferences, 81, pp. 2016.

Wiebe, E., Durepos, G. and Mills, A. J. (2010) Encyclopedia of Case Study Research. Los Angeles [Calif.]: SAGE Publications, Inc. Available at: http://search.ebscohost.com.proxy.library.dmu.ac.uk/login.aspx?direct=true&AuthType=ip,shib&db=e000xww&AN=474264&site=ehost-live (Accessed: 14 March 2019).

Wilke, T., Gottschalk, F., Groth, A., Driessen, M. & Mueller, S. 2017, "Primary Data Collection Versus use of Retrospective Claims Data: Methodology Lessons Learned from A Linked Database Study in Chronic Obstructive Pulmonary Disease (COPD)", *Value in health,* vol. 20, no. 9, pp. A651.

Wood, J. (2016). Solar energy in Germany. Refocus, 7(3), pp.24-30.

World Energy Council, 2013, World Energy Resources: 2013 Survey, World Energy Council [ONLINE]. Available at: www.worldenergy.org. [Accessed 21 March 2017].

World Solar Energy Market - Opportunities and Forecasts to 2022 - Key Players are BHEL, Tata Power, Abengoa, Areva, Canadian Solar, Motech Industries, Renesola, Solarworld & Sunways AG - Research and Markets, 2017, Energy Weekly News, pp. 684.

Wyllie, J.O.Y., Essah, E.A. & Ofetotse, E.L. 2018, "Barriers of solar energy uptake and the potential for mitigation solutions in Barbados", *Renewable & sustainable energy reviews,* vol. 91, pp. 935-949.

Zbrozek, Arthur, MSc, MBA, RPh, Hebert, J., BS, Gogates, G., BS, Thorell, R., Dell, C., Molsen, E., RN, Craig, G., Grice, K., Kern, S., BSc & Hines, S. 2013, "Validation of Electronic Systems to Collect Patient-Reported Outcome (PRO) Data—Recommendations for Clinical Trial Teams: Report of the ISPOR ePRO Systems Validation Good Research Practices Task Force", Value in Health, vol. 16, no. 4, pp. 480-489.

Zhang, Y. (2015). The regulatory framework and sustainable development of china's electricity sector. The China Quarterly, 222, 475-498.

APPENDICES

Appendix A: List of Research Publications

Journal paper:

Abdullahi, D., Suresh, S., Renukappa, S., and Oloke, D., (2021), Barriers for Implementing Solar Energy Initiative in Nigeria: An Empirical Study, *Smart and Sustainable Built Environment, Emerald publishing*, DOI: SASBE-06-2020-0094.

Conference Papers:

Abdullahi, D., Suresh, S., Renukappa, S. & Oloke, D. 2017, "Key Barriers to the Implementation of Solar Energy in Nigeria: A Critical Analysis", *IOP conference series. Earth and environmental science,* vol. 83, no. 1, pp. 12015. DOI:10.18086/swc.2017.16.01.

Abdullahi, D., Suresh, S., Renukappa, S. and Oloke, D., 2017, Solar Energy Development and Implementation in Nigeria: Drivers and Barriers. Available at: http://proceedings.ises.org. DOI:10.18086/swc.2017.16.01.

Abdullahi, D., Renukappa, S., Suresh, S. and Oloke, D., 2017, 'Power Sector Development Reforms in Nigeria: The Roots to the Challenges'. Available at: http://waberconference.com/wp-content/uploads/2018/03/WABER-2017-Conference_Proceedings.pdf. Pp.1111-1122.

Abdullahi, D., Renukappa, S., Suresh, S. and Oloke, D., 2017, Key Barrier to the implementation of renewable energy initiative in Nigeria: A critical analysis'. *Paper presented at the Nigerian Association of Energy Economic conference at PTDF conference centre Abuja*. 23 – 25 April 2017.

Abdullahi, D., Renukappa, S., Suresh, S. and Oloke, D., 2017, Status of Solar Energy Implementation in Nigeria: Drivers, Barriers and the way forward. Paper presented at the International Conference for Sustainable Design of the Built Environment (SDBE), 12-13 Sep. 2018, Crystal London.

Abdullahi, D., Renukappa, S., Suresh, S. and Oloke, D., 2017, Challenges for Implementing Solar Energy in Sub-Sahara Africa: A review from Nigeria. Paper presented at the International Conference on Construction Future (ICCF) University of Wolverhampton 19-20 Dec. 2018.

Appendix B: Invitation to participate in the research interview.

INVITATION TO PARTICIPATE IN THE RESEARCH INTERVIEW

Dear Sir/Madam,

I am a researcher (Ph.D) student at the University of Wolverhampton undertaking a research entitled: ‘‘***A framework for adopting solar energy governance in the Nigerian power sector’’*** I will like to invite you to kindly participate in an interview, as part of the research.

The interview is estimated to last for about 30- 40 minutes to discuss the challenges, barriers, drivers and benefits for solar energy initiative's implementation in Nigeria. Along with the challenges of the Nigerian Power Sector. The interview would be recorded and for academic research only. The data will be treated with strict confidentiality and no record will bear the organisation name and any other identity related to either the staff or the commission.

If you have any queries, please do not hesitate to contact me. While thanking you in advance for your time, I wait for your kind valuable assistance in this research.

Yours Sincerely,

Dahiru Abdullahi

Doctoral Research Student,

Faculty of Science and Engineering,

University of Wolverhampton

Wulfruna Street

WV1 1LY

Tel: [telephone number redacted], Email: [e-mail address redacted]

Appendix C: Organisations that participated in the research interviews.

Profiles of interviewee

S/N	Interviewee's code	Designation	Expertise	Year of Experience
1	A1, A2, A3	Director	Chief Energy Engineer	16
2	B1, B2	Assistant Director	Strategic Engineer Power Access	21
3	C	Director	Planning, Research and Statistics	15
4	D	Director	Renewable Energy Specialist	10
5	E	Assistant General Manager	Renewable Energy Regulations	16
6	F	Director	Renewable Energy Access	15
7	G1, G2	Director	Renewable Energy Programme	15
8	H	Strategic Manager	Corporate strategies and projects	12
9	I	Senior Project Mgr.	Energy Mix projects	7
10	J	Head of Renewables	Renewable Energy Access	11
11	K	Executive Director	Energy Financing	4
12	L	National Coordinator	Renewable Energy Programme	18
13	M	Deputy Director	Power generation/Transmission	16
14	N	Executive Director	Electricity management services	20
15	O	Projects Coordinator	Power Training and development	12
16	P	Deputy Manager	Sustainable Building Design	14
17	Q	Nat. Coordinator	Sustainable Energy Funds	19
18	R1, R2	Director (R & D)	Energy Efficiency & Conservation	21
19	S	Exc. Director	Energy Liability Management	23
20	T	Deputy Governor Financial	Energy Facility Management	22

Appendix D: Interview questions for solar energy organisations in Nigeria

INTERVIEW QUESTIONS

1. **Your name and background**

2. **Your designation and role in this organisation**

3. **Years of experience in the power sector**

The following questions are related to the research:

4. The Nigerian power sector has existed for a long period of time in history of interrupted power supply, in your experience, what are the key challenges associated with the industry?
5. What are the key strategies and reforms your organisation and the government have put in place to mitigate the challenges and increase access to electricity in the country?
6. In recent years, there has been an increase in solar energy deployment in the country, what are the factors that drives your organisation towards solar energy implementation?
7. Are there key initiatives/strategies you and your organisations can suggest for mitigating the solar energy implementation barriers?
8. In your opinion, what are the barriers to the implementation of solar energy initiatives in Nigeria?
9. In your opinion, what are the perceived key benefits of solar energy initiatives when it is implemented?
10. In your opinion, who are the key beneficiaries for the solar energy initiatives in Nigeria?

Appendix E: Invitation to participate in the research outcome Evaluation.

Dear Sir/Madam

We would like to invite you to participate in the evaluation of the A framework for adopting solar energy governance in the Nigerian power sector. Your identity will remain anonymous and you will not be personally identified in the final report.

Thank you for your support in previous participation and this one, we look forward to discussing with you in a few weeks.

Yours Sincerely,

Dahiru Abdullahi
Doctoral Research Student,
Faculty of Science and Engineering,
University of Wolverhampton
Wulfruna Street
WV1 1LY
Tel: [telephone number redacted], Email: [e-mail address redacted]

Appendix F: Organisations that participated in the research evaluation.

Profiles of interviewee for Framework evaluation

S/N	Position	Organisations	Years of service
1	Director; Initiatives for renewable and rural power access	A	Over 20 years
2	Assistant General Manager; Renewable Energy Regulations	E	15-20 years
3	Head of Department; Renewable energy sources	A	10-15 years
4	Executive Director; Renewable Energy financing	M	5-10 years
5	Strategic Manager; corporate strategies and projects	M	12-15 years
6	Deputy Director; Solar Energy Research	R	12-15 years

Appendix G: Interview questions for research framework evaluation

Based on our previous introductory letter on framework evaluation, I would like to ask you the following questions to enable me to ascertain the usefulness, adequacy, completeness, and feasibility of the proposed research framework to facilitate the adoption solar energy governance in Nigeria.

1. Would you say the proposed framework is useful and will help the Nigerian government to implement solar energy initiatives?
2. Would you say the proposed framework is adequate to enable solar energy stakeholders in Nigeria to adapt and implement the initiatives?
3. What is your opinion on the completeness the research framework?
4. What is your opinion on the feasibility and recommendation of the proposed research framework, any area of improvement?